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Diffusion of Innovations and Decentralized Green Stormwater Infrastructure: a Case Study of the Headwaters of Waller Creek Watershed, Austin, Texas.

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Diffusion of Innovations and Decentralized Green Stormwater Infrastructure: a Case Study of the Headwaters of Waller Creek Watershed, Austin, Texas.

by

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Abstract

Diffusion of Innovations and Decentralized Green Stormwater Infrastructure: a Case Study of the Headwaters of Waller Creek Watershed, Austin, Texas.

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The University of Texas at Austin, 2017

Supervisor: Robert Young

This Report was undertaken as partial fulfillment of the requirements for the degree of a Master of Science in Community and Regional Planning and also as an investigation into how the City of Austin's Watershed Protection Department (WPD) can advance the particular goals of their Pilot Project: "Rain Catcher". The Report explores and discusses: 1) the ways in which infrastructure in cities has been regarded and constructed over time, 2) how these perspectives and approaches have influenced stormwater management in the United States, 3) what this has entailed in the case of Austin, Texas, specifically and 4) what are the current barriers and opportunities for the WPD Rain Catcher Pilot Project. With this Pilot Project, the WPD seeks to understand if installing green stormwater systems (e.g. rain gardens and cisterns) on private and public parcels is a feasible alternative service delivery model for stormwater management. To identify the potential barriers and opportunities (i.e financial, technical, cultural, etc.), this study conducted a survey of residents in the headwaters of Waller Creek. In order to interpret the survey results and provide recommendations to WPD, I applied the social science theory Diffusions of Innovations.

Results of the survey indicate that the diffusion process of rain gardens and cisterns is in its early stages. Relatively few respondents had already adopted these green stormwater systems (GSI) at their residences and even fewer had familiarity with what constituted a rain garden. Despite this, there was a willingness by a majority of those surveyed to install GSI. The primary obstacles facing greater adoption expressed by residents are 1) cost 2) maintenance 3) help with installation. These practical barriers

were also mirrored in people's yard management: money, time, and knowledge were identified as the three primary reasons why respondents did not have their "ideal yard". Currently, the majority of respondents do not manage yards that are eco-centric and instead prioritize convenience and keeping costs low. Notable distinctions were revealed between adopter categories (innovators, early adopters, late majority/laggards) however: innovators do value yards that are more eco-centric, ones that can provide a variety of ecosystem services. Additionally, innovators and early adopters had greater levels of education, were wealthier and younger.

Diffusion of Innovation theory can provide a framework for the WPD to encourage the greater adoption of GSI. For example, tailoring these GSI to have greater "relative advantage" (i.e. by lessening yard management costs or maintenance needs) would encourage adoption. Reducing the "complexity" of these systems (either in how they are perceived or in terms of providing assistance in their installation, for example), will also help in this regard. To enable greater "compatibility" for GSI, in terms of cultural and social norms, could entail not only simplifying these systems but also promoting yard management practices that are more eco-centric. Finally, Diffusion of Innovation literature suggests that also providing more "trialability" and "observability" opportunities of rain gardens and cisterns will aid in their adoption.

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Chapter 1: Introduction

Our greatest need today is to see life as whole, to see its many sides in their proper relations; but we must have a practical as well as a philosophical interest in such an integrated view of life.[1]
Patrick Geddes

Water is always irreducibly figurative and inescapably literal, constructed and real, fabulous and mundane, and profoundly cultural.[2]
Carl Smith

The Overview Effect[3]

By the year 2030 it is expected that nearly two thirds of the entire world's population will live in cities. As it currently stands, already more than three quarters of North Americans live in urban areas.[4] Perhaps this does not come as a surprise. It is after all, a trend that began over one hundred years ago soon after the Industrial Revolution. What may be surprising however, is that nearly 83% of the Earth's entire land surface is now in some way affected by human settlements and activities.[5] Indeed, the degree of humanity's impact on the planet is so dramatic that we have entered what many geologists have deemed the "Anthropocene": a new geologic age defined as the period of time that human activity has been the dominant influence on climate and the environment.[6] Today decisions made by, in, and for cities with regards to such things as food and energy production, water supply or water treatment, or raw materials for industry for example, have significant and tangible social, economic, and environmental, ramifications far beyond just their immediate physical boundaries.[7] As these urban areas continue to grow these decisions carry all the more import. The need for sustainable and

[1] Mairet, Philip. "Pioneer of sociology: the life and letters of Patrick Geddes". *Hyperion Press*, 1957., I
[2] Smith, Carl. "City water, city life: water and the infrastructure of ideas in urbanizing Philadelphia", *Boston, and Chicago*. University of Chicago Press, 2013., 2
[3] The Overview Effect is defined as: a profound psychological shift in awareness experienced by astronauts while observing the Earth from orbit. (Shaw, 2017)
[4] Casselman, Anne. "What is stormwater runoff and why does it matter?", *Expeditions*, Scientific American. Oct 2010. Web. Aug 2017., 1
[5] De Sherbinin, Alex. "A CIESIN thematic guide to land-use and land-cover change (LUCC)." *Center for International Earth Science Information Network*, Columbia University, 2002, 2
[6] Steffen, Will, Paul J. Crutzen, and John R. McNeill. "The Anthropocene: are humans now overwhelming the great forces of nature." *AMBIO: A Journal of the Human Environment* 36.8 (2007): 614-621., 615
[7] National Research Council. "Urban stormwater management in the United States." *National Academies Press,* 2009., 112

resilient solutions in design and city planning therefore is increasingly clear, if not at this point imperative.

The reality we know today is a product of what Urban Ecologist and Geographer Maria Kaika characterizes as: the "Promethean Project of Modernity".[8] Modern cities specifically, in her view, represent the physical manifestations of efforts made during the last two centuries to tame what was considered a separate and often hostile "nature". Nature during this period, was commonly perceived as "uncontrolled" and "undisciplined", often the root of poor social and environmental conditions in budding cities, and an impediment to urban development and notions of progress.[9] To realize progress and enter modernity therefore, it required the construction of large-scale infrastructure networks and technical systems –systems that encompassed water, sewer, transportation, communication, and electricity services.[10] These were and very much still are, technical and engineering marvels, intended to enable and improve the material, physical, and even moral, conditions of urban citizens.[11]

In addition to the dramatic physical transformation that took place in cities during this "great age of urbanization"[12] came another significant development that unfolded in parallel. In his book "City Water, City Life", historian Carl Smith identifies this development as a cultural shift, entailing a psychological separation between humans and nature that was reinforced by the emerging physical forms and functions of city infrastructure. Nature slowly became romanticized and relegated to a very particular mental categorization. Water infrastructure in particular represents this evolving relationship, as Smith articulates: "city water blurred the line between nature and the built environment"[13] such that "waterworks systems denaturalized it into an apparently manufactured commodity that was sold, delivered, used, and discarded."[14] As water became dredged, dammed, drained, and redirected, people's interactions with it and nature in general, became planned and programmed in the form of gardens, parks,

[8] Kaika, Maria. "City of flows: Modernity, nature, and the city." *Psychology Press*, 2005., 6
[9] Kaika, 6
[10] Kaika, 6
[11] Karvonen, Andrew. "Metronatural™: Inventing and reworking urban nature in Seattle." *Progress in Planning* 74.4 (2010): 153-202, 154
[12] Smith, 2
[13] Smith, 5
[14] Smith, 5

fountains, artificial water features, etc. The physical and psychological separation between humans and nature is still clearly evident in the connection between city dwellers and their water today, though there are early signs that this modern divide may be evolving.

We find ourselves now in the waning period of what Maria Kaika considers the third of three phases in the Promethean Project of Modernity: what she deems as "Modernity's Promethean Project Discredited".[15] It is a period of time distinguished by aging infrastructure, significant demands on finite resources, global warming, and a growing frequency of environmental disasters. To take on these modern challenges, cities are increasingly aiming to implement policies, practices, and infrastructure that are both "sustainable" and "resilient". Built upon the planning and design ideas of early influential thinkers such as Aldo Leopold, Ian McHarg and Patrick Geddes,[16] these strategies seek to address today's social, ecological, and economic issues by reducing demands on resources, enhancing people's connections to landscape and place, and improving overall quality of life.[17] Sustainable and resilient approaches mark a departure from the past, as they aim to include and re-introduce nature and natural elements in the form of infrastructure at the building, site, city, and regional scales.[18]

However, despite the apparent need for and value of more sustainable and resilient approaches, many obstacles remain in making cities more natural and nature-full.[19] In some cases they may be legal or regulatory barriers, where for example because of existing zoning codes there are minimum parking or road width requirements. In other cases it may be economic, where due to the relative newness of these strategies initial design and construction costs are more expensive than traditional approaches.[20] One of the less obvious obstacles preventing greater application however, are the people who live in cities themselves.[21]

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[15] Kaika, 6
[16]Steiner, Frederick R , George F. Thompson and Armando Carbonell. "Nature and Cities: The Ecological Imperative in Urban Design and Planning". *Lincoln Institute of Land Policy.* 2016., 2
[17]Beatley, Timothy, and Peter Newman. "Biophilic cities are sustainable, resilient cities." *Sustainability* 5.8 (2013): 3328-3345., 3328
[18]Beatley, 3328
[19] Beatley, 3342
[20] Environmental Protection Agency. "Overcoming Barriers to Green Infrastructure". *Environmental Protection Agency.* N.d. Web. Oct 2017. , 1
[21] Beatley, 3342

Green infrastructure is in many ways a novelty and does not have the public acceptance that traditional infrastructure holds.[22] Because of this it is increasingly recognized today that a successful transition will also involve amending the past cultural and psychological divide that developed between urbanites, water, and nature. This will be a transition achieved by understanding and adjusting to public perception and values: through outreach, education, monitoring, and inter-governmental coordination.[23] If successful, these efforts potentially represent the beginnings of a fourth phase of modernity, one that embraces what Urban and Environmental Planning Professor Timothy Beatley calls: the "biophilic city". Going beyond sustainable design and ecological intervention, biophilic cities foster human engagement with, value of, and closeness to nature.[24] The city of tomorrow, those that may be the best hope for addressing some of today's pressing sustainability problems, may in fact require further Promethean efforts, but this time to restore and redefine our personal and societal orientations towards nature in the city.

Austin: A Case Study

The City of Austin finds itself right at this particular juncture in urban history. In fact "citywide sustainability" is a "core value" to the city, with efforts already underway to make it the "greenest, most livable city" in the country.[25] To serve as a road map the City adopted a comprehensive plan –Imagine Austin- in 2012, which is guiding the way growth and development takes place over the next thirty years. In the plan there are eight "priority programs" and two address water and the environment directly. Within these two priority programs, it is listed that "sustainably managing our water resources", "using green infrastructure to protect environmentally sensitive areas", and "integrating nature into the city" are goals to strive for.[26] This paper investigates one effort that has sprung from Imagine Austin and these two priority programs: the Watershed Protection Department's (WPD) Rain Catcher Pilot Project in the headwaters of Waller Creek. The

[22] Copeland, Claudia. "Green Infrastructure and Issues in Managing Urban Stormwater". *Congressional Research Service.* May 2016., 6
[23] Copeland, 7
[24] Beatley, Timothy. "Leaf Litter Talks 'Biophilic Cities' with Timothy Beatley". *Biohabitats. Winter Solstice Vol. XI. Edition 5.* 2013. Web. Oct 2017*., 1*
[25] Citywide Sustainability. *City of Austin.* N.d. Web. Oct 2016. http://www.austintexas.gov/department/citywide-sustainability
[26] Gonzalez, Ana. Personal Communication. 30 Nov. 2017.

primary goal of the WPD in this effort is to test an alternative service delivery model for stormwater management with the application of decentralized green infrastructure: specifically, rain gardens and cisterns on both private and public parcels. What is also noteworthy, is that the Rain Catcher Pilot Project is designed to maximize community participation and raise public awareness about the value and benefits of healthy streams and stormwater stewardship.[27] It is the hope of the WPD that individuals will embrace and install these green infrastructure systems at their residences, however at this point, it is unknown to what extent they will be willing to do so. To explore what, if any, may be the barriers or opportunities towards meeting WPD objectives, this study conducted a survey of those residents in the headwaters of Waller Creek. In order to interpret the survey results and provide recommendations to WPD, I applied a social science theory known as Diffusions of Innovations.

[27] Scoggins, M., and Ana Gonzalez. Personal Communication. 1 Nov. 2016.

Chapter 2: Stormwater

The fundamental problem with conventional stormwater management may be the mindset. It does not treat water as a valuable resource but more like a problem to solve, or even worse, seeks to export it as a waste product.[28]
Steven I. Apfelbaum

Urban runoff is part of the larger debate over the dilemma of urban nature and the tensions between nature, technology, and humans in cities.[29]
Andrew Karvonen

Stormwater Management: An Introduction

Currently in the United States the Environmental Protection Agency has designated approximately 13 percent of rivers, 18 percent of lakes, and 32 percent of estuaries as unsafe for swimming or fishing. It is an unfortunate state of affairs that can be attributed almost entirely to urban stormwater runoff. Despite the fact that urban areas cover only three percent of the land mass in the US,[30] extreme cases make clear how significant this source of contamination can be. In the Puget Sound off the coast of Seattle for instance, upward of 75 percent of found toxic chemicals are due to stormwater runoff. [31] The Los Angeles River alone, to offer another stark example, is responsible for one percent of the total petroleum hydrocarbon input into the ocean annually.[32]

It is evident that traditional approaches towards managing stormwater are not up to meeting this modern challenge. As this becomes clearer cities are beginning to consider more sustainable and ecological strategies for stormwater management: specifically, through the application of decentralized green infrastructure. To do so successfully, entails a dramatic shift in not only the physical infrastructure used but also an evolution in the relationship between water and people in cities.[33] Adopting an ecological and sustainable approach towards stormwater emphasizes the interconnectedness of an urban landscape and recognizes that the management of

[28] Apfelbaum, Steven, "Stormwater Management: A Primer and Guidelines for Future Programming and Innovative Demonstration Projects*"..Rowman & Littlefield*, Lanham, Maryland, 2005., 321
[29] Karvonen, Andrew. "Politics of urban runoff: nature, technology, and the sustainable city." *MIT Press*, 2011., viii
[30] National Research Council. "Urban stormwater management in the United States." *National Academies Press,* 2009., 21
[31] Casselman, Anne. "What is stormwater runoff and why does it matter?", *Expeditions*, Scientific American. Oct 2010. Web. Aug 2017., 1
[32] Casselman, 1
[33] Karvonen, 19

stormwater must now be informed by cultural, political, and ecological knowledge, as much as technical expertise.[34] This is in part due to the fact that municipal and regional green infrastructure programs are finding the need to have greater participation and buy-in from local residents.[35] How to motivate people towards greater adoption of green infrastructure however remains one of the biggest challenges facing cities and their stormwater management programs.

Stormwater Runoff: A Definition

Precipitation on undeveloped landscapes will infiltrate the ground, undergo natural filtration, and eventually continue on to either replenish aquifers or contribute to rivers, lakes, or streams. In cities however increasing amounts of impervious cover have altered this natural flow of events.[36] Instead, by preventing infiltration -and therefore reducing the water-retaining and evapotranspirating functions of soil and vegetation- these surfaces create stormwater runoff.[37] This runoff can then carry accumulated organic matter, fertilizers, pesticides, oil and grease, and other contaminants found on parking lots, roads, driveways, etc., directly into streams and water bodies. Additionally, because preexisting hydrologic regimes[38] in these urban settings are completely transformed there is often habitat degradation along waterways[39] and the potential for more frequent and larger floods. [40] In short, stormwater runoff is water that has precipitated to the ground and then been influenced by human activities, in human-disturbed watersheds, and to the detriment of humans and the environment.[41]

Stormwater Management: A Brief History

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[34] Karvonen, 29
[35] Turner, Kelly, Kimberly Jarden and Anne Jefferson. "Resident perspectives on green infrastructure in an experimental suburban stormwater management program." *Cities and the Environment.* 9 (1). 2016, 3
[36] Miller, Keith, Kristina Costa, and Donna Cooper. "How to Upgrade and Maintain our Nation's Wastewater and Drinking-Water Infrastructure." *Washington: Center for American Progress*. 2012., 8
[37] National Research Council, 4
[38] Hydrologic Regimes refers to streamflow quantity and timing and is considered a critical variable in maintaining healthy, aquatic ecosystems. These regimes are determined naturally by many factors, including river size and geographic variation in climate, geography, topography, and vegetative cover. (Poff, 770)
[39] Karvonen*, vii*
[40] Flinker, Peter. "The Need to Reduce Impervious Cover to Prevent Flooding and Protect Water Quality." *AICP Dodson Associates, LTD*. 2010., 3
[41] National Research Council, 12

To cope with the consequences of urbanization, impervious cover, and stormwater runoff, we have what is now considered "stormwater management", though it was once more widely thought of as simply "urban drainage".[42] Until only recently city stormwater systems were designed and constructed primarily to quickly convey and drain rain water away from people, property, and flows of commerce.[43] With this nearly myopic focus on flood control and prevention stormwater systems were usually composed of a combination of catch basins[44] and pipes intended to simply deliver stormwater to the nearest waterways.[45] These waterways were then often widened, buried, or lined with concrete, to further ensure the quick conveyance of water.[46] Additionally, stormwater infrastructure was a commonly used and practical means to drain sewage out of cities as well. Combined sewer systems (CSSs), built as recently as mid-20th century, were considered convenient and cost efficient strategies to transport common "urban liquids" by using stormwater runoff.[47] In this sense rainwater that falls in modern cities has been and in most cases still is considered at best a convenient tool or at worst a threat to be mitigated, but rarely as a resource that can or should be valued.[48]

Predominantly this is still the perspective and these are still the stormwater systems that cities rely on, use, and maintain today. Unfortunately, while this approach may have seemed economical or rational at the time, there have been unforeseen consequences that city's are now reckoning with. To quickly convey water in this manner, for example, means that stormwater runoff will typically arrive at stream channels or receiving waterbodies in "short, concentrated bursts of high discharge."[49] Because of this these stormwater systems can cause and even exacerbate infrastructure damage, habitat destruction, stream-bank erosion, and downstream flooding.[50] Furthermore, traditional approaches have the potential to degrade water quality in local

[42] Karvonen , 11
[43] Karvonen , vii
[44] Catch basins are essentially receptacles, reservoirs, basins, pits, or vaults, beneath surface storm drain openings. Their function: to trap trash or sediment before entering local waterways. These basins are accessible from ground level, so they may be cleaned out. (Pekarek, 2)
[45] National Research Council, 283
[46] Karvonen, viii
[47] Echols, Stuart, and Eliza Pennypacker. "The History of Stormwater Management and Background for Artful Rainwater Design." *Artful Rainwater Design*. Island Press/Center for Resource Economics, 2015. 7-22., 10
[48] Karvonen, 11
[49] National Research Council, 4
[50] Environmental Protection Agency. "EPA facility Stormwater Management". *Greening EPA*. Mar 2017. Web. Aug 2017., 1

water bodies to an extent that approaches the quality of untreated human sewage (in terms of total suspended solids or nutrients).[51] Combined sewer systems, despite their logical design, have over time not been ideal either. Occurrences of CSS overflows, brought about by significant rain events, have led to sewage being returned to its source or alternatively being released into the closest streams, rivers, lakes, or receiving waterbodies.[52] Ultimately, it wasn't until the late twentieth century when there began to be greater recognition that this approach and perspective towards rain and stormwater runoff was flawed.

Stormwater Management Today: From "Urban Drainage" to "Stormwater Management"

The Federal Clean Water Act (CWA), passed in 1972, represents the first significant step taken to rectify some of the problems caused by these past strategies and perspectives toward stormwater runoff. After subsequent amendments in 1977 and 1987 it also remains the primary federal means to regulate the quality of the nation's waterbodies[53] and provides the blueprint for how states, and their cities, manage stormwater.[54] The act's immediate intent is to limit discharges of pollutants and set quality standards for surface waters in the United States. The long term objective is to restore and maintain the chemical, physical, and biological integrity of the nation's waters, to the extent that water quality can be considered both "fishable" and "swimmable".[55] To do so each state is required to establish a Total Maximum Daily Loads (TMDLs) Program, which entails first identifying waters that are impaired or at risk and then to calculate and work towards pollutant reduction levels.[56] Also because of the CWA, operators of municipal separate storm sewer systems (MS4s) –which includes nearly all urban areas or locations with a population above 10,000 and density of 1,000

[51] Carlson, Cynthia, et al. "Storm water management as a public good provision problem: survey to understand perspectives of low-impact development for urban storm water management practices under climate change." *Journal of Water Resources Planning and Management* 141.6, 2014., 2
[52] Echols, 11
[53] National Research Council, 15
[54] Carlet, Fanny. "Understanding perceptions and adoption of green stormwater infrastructure." *Diss. Virginia Polytechnic Institute and State University*, 2014., 12
[55] National Research Council, 39
[56] Environmental Protection Agency. "Impaired Waters and TMDLs". Jan 2017. Web. Aug 2017. , 1

people per square mile[57]- must acquire from the Environmental Protection Agency (EPA) National Pollution Discharge Elimination System (NPDES) permits and develop stormwater management programs (SWMP). More specifically, it is a requirement that the SWMPs are founded on measurable goals and supported by best management practices (BMPs).[58]

Since the CWA's passing significant progress has been made to improve the quality of the nation's waters.[59] However as stated earlier, a substantial amount of our waters still do not meet water quality standards, standards that are set to protect not only aquatic ecosystems but also public health.[60] As a result the Environmental Protection Agency, states, and cities, are beginning to innovate and promote more unconventional stormwater management strategies to aid, improve, or replace existing traditional stormwater infrastructure.[61] The newer approaches are intended to essentially counteract the impact of impervious surfaces by mimicking natural hydrologic and ecological systems.[62] Known as "low-impact development (LID)"[63] strategies, they can address runoff volumes, peak flows, and improve water quality through techniques that facilitate water entering the ground[64] and as close to the source as possible.[65] In application this entails a significant break from the past, one that relies heavily on green stormwater infrastructure (both natural and constructed), in a more decentralized manner, to preserve or recreate the features of a natural landscape.[66]

Green Stormwater Infrastructure

The EPA describes green stormwater infrastructure (GSI) as: "a comprehensive approach to water quality protection defined by a range of natural and built systems that

[57] Environmental Protection Agency. "Stormwater Phase II Compliance Guide" *Environmental Protection Agency*. 2000.. 2-3
[58] Cartlet, 1
[59] National Research Council, 17
[60] National Research Council, 17
[61] National Research Council, 285
[62] Carlson, 2
[63] Low Impact Development is an umbrella categorization that encompasses green infrastructure, conservation design, and generally sustainable stormwater management. Generally speaking, LID strategies, at both site and regional scales, are an approach to land development that works with nature and treats stormwater as a resource rather than a waste product. (USEPA 2007, 1)
[64] Niemczynowicz, Janusz. "Urban Hydrology and Water Management: Present and Future Challenges " *Urban Water*. no. 1 (1):1-14. 1999., 3
[65] Environmental Protection Agency, "Urban Runoff: Low Impact Development". *Polluted Runoff: Nonpoint Source Pollution*. Jun 2017. Web. Aug 2017., 1
[66] Environmental Protection Agency Jun 2017, 1

can occur at the regional, community, and site scales."[67] At regional or community levels, strategies can include the development of habitat corridors or planning and design approaches such as mixed-use development. At the site scale, the types of GSI strategies that are commonly applied includes rain gardens, disconnected roof drains, porous pavements, green roofs, bio-swales, infiltration planters, trees and vegetation, and rain water harvesting tools (i.e. cisterns or rain barrels). As part of a larger comprehensive stormwater management system these site level strategies can, in the aggregate, effectively help to address the modern problems associated with stormwater runoff by serving to retain and infiltrate rainfall.

GSI has also been recognized for having even broader environmental, social, and economic benefits as well. Unlike traditional gray stormwater infrastructure[68] this form of stormwater management provides a range of "ecosystem services", or "the benefits human populations derive, directly or indirectly, from ecosystem functions."[69] These ecosystem services and their benefits can be collectively classified into four broad categories: provisioning, regulating, supporting, and cultural.[70] GSI specifically not only aids in reducing stormwater volume and improves water quality but can also filter air pollution, reduce energy demand, alleviate urban heat islands, sequester carbon, support biodiversity, and provide aesthetic, spiritual, and monetary value for people.[71] Rain gardens[72] for example, can filter runoff pollution (regulating service), create habitats for birds and butterflies (supporting services), increase property value (cultural), and even provide food (provisioning). Cisterns[73] too offer many of the same advantages: by

[67] Hall, Abby. "Green infrastructure case studies: municipal policies for managing stormwater with Green Infrastructure." *Environmental Protection Agency.* 2010., 2

[68] Gray infrastructure generally refers to the materials used in the construction (i.e. concrete or steel) of the networks of structures or facilities that provide us with defined services or products (i.e. electricity or drinking water). (Wolf, 2)

[69] Costanza, Robert, Ralph d'Arge, Rudolf deGroot, et al. "The value of the world's ecosystem services and natural capital." *Nature.* 387:253-260. 1997., 253

[70] Raudsepp-Hearne, C., Garry D. Peterson, and E. M. Bennett. "Ecosystem service bundles for analyzing tradeoffs in diverse landscapes." *Proceedings of the National Academy of Sciences.* 107.11 (2010): 5242-5247., 5243

[71] Dunn, Alexandra Dapolito. "Siting green infrastructure: legal and policy solutions to alleviate urban poverty and promote healthy communities." *Boston College Environmental Affairs Law Review.* Vol 37. 2010., 41

[72] A rain garden is a depressional area that absorbs and filters rain water runoff that comes from roofs, sidewalks, and/or driveways. Rain runs off the hard surfaces, collects in the shallow depression, and slowly soaks into the soil. Often they are landscaped with perennial flowers or native vegetation to help soak up rainwater. (Natural Resrouces Conservation Service, 1)

[73] Rainwater harvesting cisterns collect rainwater from roofs or other catchment areas and holds it. This water can either be allowed to slowly infiltrate into the ground or be available for individuals to use at a later date. Cisterns can aid in pollution control, volume reduction, and peak flow reduction. They can be located underground, placed at ground level, or on elevated stands. (Stormwater Management Academy, 1)

storing and holding rain they save water for later use (provisioning), allow rain to infiltrate the ground gradually to filter the water and replenish vegetation (regulating and supporting), and can contribute to a sense of place (cultural). Despite the fact that this range of ecosystem services provided by green stormwater infrastructure is well documented however, there remains a number of barriers to its greater diffusion and implementation.

First and foremost, because effective stormwater management strategies now necessitate the incorporation of a decentralized approach at site scales, it is apparent that cities must for the first time also include residents as active participants in the management of stormwater.[74] Yet, the extent to which individuals will participate and adopt these alternatives to conventional landscaping choices remains a great unknown.[75] Until recently there has been little research conducted that examines residents' values, attitudes, and perceptions towards GSI and how this relates to its adoption.[76] Furthermore, cities have in the past framed stormwater management as a technocratic or engineering issue, and not as a "collective actions problem"[77], establishing a perspective that views stormwater management as solely the responsibility of the city and not of the individual.[78] This challenge is compounded by the fact that the CWA and NPDES are unfunded mandates and unlike in the past when significant investments were made in public infrastructure, today there is relatively little money available to fix even existing infrastructure let alone support more unconventional GSI.[79]

Even if the mandates were well funded though, in those cases where GSI has been available for free or with incentives, participation by residents in municipal green infrastructure projects has still been low.[80] Reasons for this limited degree of participation have so far been attributed to an assortment of biophysical and social factors

[74] Porse, Erik, "Stormwater governance and future cities." *Water.* 5.1 (2013): 29-52., 35
[75] Turner, ii
[76] Turner, 5
[77] A "collective action problem" describes scenarios where there is conflict between the individual interest and the group interest. Common to environmental issues, it usually involves individuals who would act in their own self interest while the group would benefit from environmental protection. (Tschakert, 1)
[78] White, D.D. "Framing Water Sustainability in an Environmental Decision Support System." Society & Natural Resources, 26: 1365–1373. 2013. , 1366
[79] Abhold, Kristyn, Lorraine Loken and Ben Grumbles. "Barriers and Gateways to Green Infrastructure." *Clean Water American Alliance.* Washington, DC. 2011., 7
[80] Bos, Darren, and Helen Brown. "Overcoming barriers to community participation in a catchment-scale experiment: building trust and changing behavior." *Freshwater Science*, 34(3):1169-1175. 2015. , 1174

(institutional, socio-cultural, and socio-cognitive), which can affect an individual's willingness to install and manage GSI at their residences.[81] This diversity of factors influencing landscape choices can include such things as aesthetic preferences, social norms and experiences, and factors specific to lifestyles such as socioeconomic status, family structure, and leisure activities.[82] Even if, for example, an individual expresses strong environmental values or concerns, this does not necessarily lead to pro-environmental behavior in residential landscaping choices.[83] This individual may instead, due to other lifestyle ideals or social pressure, prefer the functionality and aesthetics of a manicured, grassy, well fertilized, well watered, lawn. In sum, when it comes to people and how they manage their yards, landscape preferences will represent a diverse set of influences and worldviews and often reflect a contradiction between an individual's values and choices.[84] Unlike traditional approaches towards stormwater management therefore, successful GSI implementation plans now require an understanding of unique social and cultural dynamics and an ability to adapt to local contexts.[85] By garnering this kind of understanding, education specialists, planners, and city stormwater managers alike, can begin to develop and implement strategies that overcome institutional, socio-cultural, and socio-cognitive barriers in the adoption of GSI and work towards a more sustainable approach to stormwater management.

[81] Baptiste, April. "Experience is a great teacher: citizens' reception of a proposal for the implementation of green infrastructure as stormwater management technology." *Community Development*, 45: 337–352. 2014., 338
[82] Larson, Kelli. "Residents' Yard Choices and Rationales in a Desert City: Social Priorities, Ecological Impacts, and Decision Tradeoffs." *Environmental Management. 44:921-937. 2009., 924*
[83] Turner, 5
[84] Larson, 924
[85] Carlson, 1

Chapter 3: Austin

My object, the sole and only desire of my ambitions since I first saw Texas, was to redeem it from the wilderness—to settle it with an intelligent and enterprising people.[86]
Stephen F. Austin

Of all the endeavors on which I have worked in public life, I am proudest of the accomplishment in developing the Colorado River…This is the true fulfillment of the true responsibility of government.[87]
Lyndon B Johnson

Change isn't easy. Actively preparing for change and uncertainty can be tough. However, the potential rewards can outweigh the discomforts. Choosing a different path for our city will require doing things differently. Having imagined a better Austin, it is incumbent upon us to realize our vision.[88]
Imagine Austin Comprehensive Plan

Austin: An Introduction

Water and nature have had and continue to play an inextricable role in the story of Austin, Texas. This is true not only in the development of the city's physical form but also in terms of its enduring influence on and role in the city's economy, culture, and in the daily lives of its people. It is water that wealds the city's charm and magnetism, most notably manifested in Barton Springs, the Greenbelt, or Ladybird Lake, and it is water - and the city's efforts to contain and control it- that has enabled Austin's remarkable population growth, determined its economic fate, and wrought many of the biggest challenges it faces today.

The story of stormwater in Austin exemplifies the changing way in which some cities and their residents are beginning to think about, value, and approach nature and water and also mirrors how stormwater management strategies are evolving at the national level. In Austin specifically, there are two political and cultural undercurrents that have driven this discourse and wrought tangible outcomes. The first is a perspective

[86]Kelley, Michael G. "Most desperate people: The genesis of Texas exceptionalism". *Georgia State University*, 2011, 18
[87] Karvonen, 43
[88] City of Austin. "Imagine Austin Comprehensive Plan: Vibrant, Livable, Connected.", *City of Austin.* 2016., 6

that prioritizes economic growth and property rights[89] and the second, an environmental ethic and belief that the local natural landscape contributes to a unique culture and sense of place and is therefore worthy of protection.[90] This dynamic has determined how the city has grown and led to the preservation of Austin's beloved natural wonders, such as Barton Springs and the Greenbelt. What was lacking historically however, both in the culture of Austin and in the city's regulatory approaches, is an understanding of urban ecology and a recognition of a landscape that is interconnected.[91] For this reason, Austin now contends with water quality, habitat degradation, and flooding issues that are a result of past development, impervious cover, and the associated stormwater runoff. While the city has made significant strides in terms of its regulatory approach much of Austin was developed before these regulations were in place, leaving a legacy of degradation.[92] Presently though, the city of Austin "is at the cusp of a big protection and fiscal paradigm shift",[93] a shift that may address these issues through a greater reliance on decentralized green infrastructure and public buy-in. The success of this new path forward is yet to be determined but will necessitate greater involvement and participation from Austin's citizens and likely hinge on how nature and water are valued in Austin.

In the Beginning was the Water

Since the city's founding Austin's relationship with water has enabled, hindered, and shaped, the physical form of the city. In fact the original location of Austin itself, established in 1839, was chosen for the three waterways that would serve as the early boundaries of the city: Shoal and Waller Creek to the West and East, respectively, and the Colorado River to the South. These waterways provided the location its appeal with "natural beauty, seeming healthfulness, and an abundance of natural resources".[94] However, because of a particularly unique set of geographic and atmospheric circumstances, these same "sheltering arms"[95] –as one early founding document

[89] Rodgers, Scott. "Urban growth machine." *Birkbeck. University of London.* 2009: 40-45., 40
[90] Karvonen, 45
[91] Karvonen , 62
[92] Gonzalez, Ana. Personal Communication. 30 Nov. 2017.
[93] Hollon, Matt. Personal Communication. 28 Oct. 2016.
[94] Humphrey, David. "Austin, TX (Travis County)" Handbook of Texas Online, *Texas State Historical Association*, Jun 2010. Web. Aug, 2017, 1
[95] Hart, Katherine. "Waterloo Scrapbook 1973-1974." *Austin: Friends of the Austin Public Library 1974*., 24

describes the waterways- would reveal themselves also as great threats and have unexpected and dramatic influence over the city's development.

The unique climactic situation just referenced is considered a climate transition zone. In this particular transition zone moisture from the Gulf of Mexico and the Pacific crash into dry west Texas air over the Balcones Escarpment, a stretch of uplifted terrain extending through Austin and much of central Texas.[96] Due to these conditions, rain does not fall in regular storms throughout the year[97] but instead intermittently and in short dramatic bursts, delivering some of the "largest flood-producing storms in the US."[98] The threat that this presented to early Austin residents was considerable and acted as a catalyst for their very own Promethean approaches to subdue nature and the city's waterways.[99] These efforts -made during the late 19th century and early 20th century- were relatively successful at protecting lives and property from floods and served as the springboard that launched Austin into the future.

Prometheus Visits Texas

The Colorado River arrives in Austin after a five hundred mile journey from West Texas, serving as catchment for 39,900 square miles of the state along the way. Before being allowed to continue on to the Gulf of Mexico as it once did however, the river now flows up against a series of six dams, constructed as New Deal projects during the Progressive era in the 1930s and 40s. These dams, built by the charisma of Lyndon Baines Johnson and with significant amounts of funding from the Public Works Administration, compose what we know today as the Highland lakes: a hundred-and-fifty-mile chain of water bodies extending just North West of Austin.[100] With these dams not only had the Colorado River been tamed and the threat of floods diminished, but Austin could now provide ample water and electricity services. One hundred years after its establishment, Austin finally had a foundation to support economic development and realize a dormant potential for growth.

[96] Fry, 109
[97] Karvonen, 41
[98] Karvonen, 41
[99] Karvonen, 41
[100] Karvonen, 41

And grow it did. By harnessing the Colorado's water the table was set for recreational, agricultural, commercial, and other industries to flourish. Austin suddenly became a destination and from the year 1940 until the year 2000 the city increased in size by nearly 40 percent per decade.[101] Most recently, estimates by the city's demographers office predict that by 2020 the population will exceed one million for the first time in its history. There is no end in sight either, as Austin continues to be one of the fastest growing urban areas in the United States.[102]

While this dramatic growth has been accompanied by accolades, national attention, and a place on nearly every list of top cities in America,[103] the manner in which it has occurred has also had fairly significant and negative repercussions. Austin has primarily grown out and not up, following a pattern of development that has transpired in similar ways across the United States. Roads and highways often act as harbingers of sprawl[104] and as evidenced by the following Figures 1 and 2, Austin has urbanized in just such a predictable manner, most notably along I-35, HW1, 183, and Highway 71.

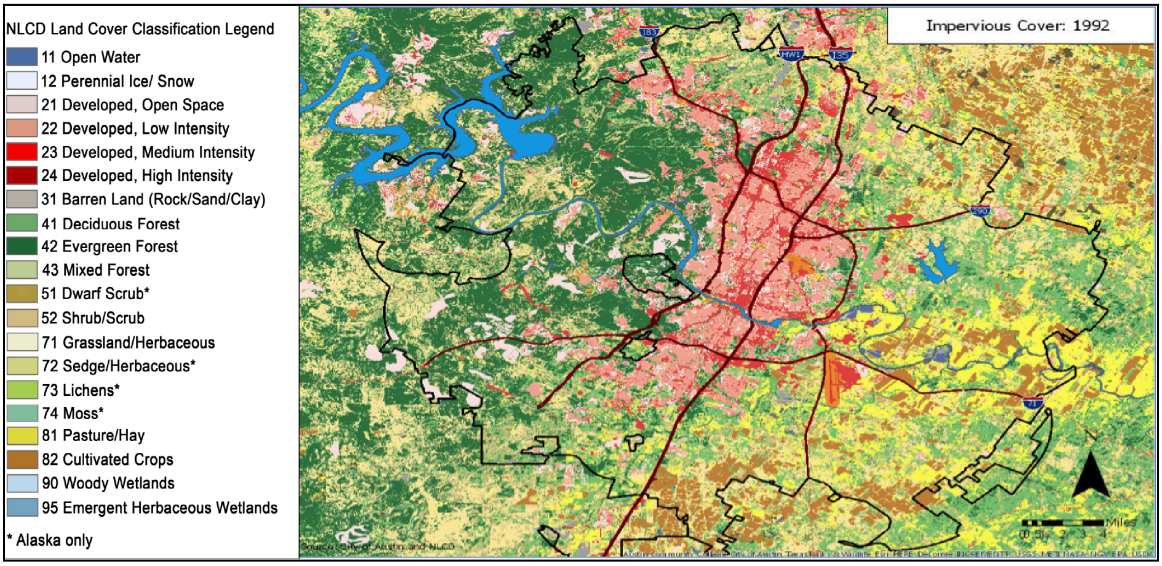

Figure 1. Impervious Cover over Austin in 1992[105]

[101] Karvonen , 44
[102] Theis, Michael. "Austin Remains Population Magnet- but growth in the 'burbs is far swifter." *Austin Business Journal.* Dec 2016. Web. Aug 2017., 1
[103] Roots Real Estate. "Austin Accolades". N.d. Web. Aug 2017., 1
[104] Bhatta, Basudeb. "Analysis of urban growth and sprawl from remote sensing data." *Springer Science & Business Media*, 2010., 24
[105] Land cover data was retrieved online from the National Land Cover Database while files on Austin's 2016 Extra Territorial Jurisdiction (ETJ) were retrieved through the city GIS database online.

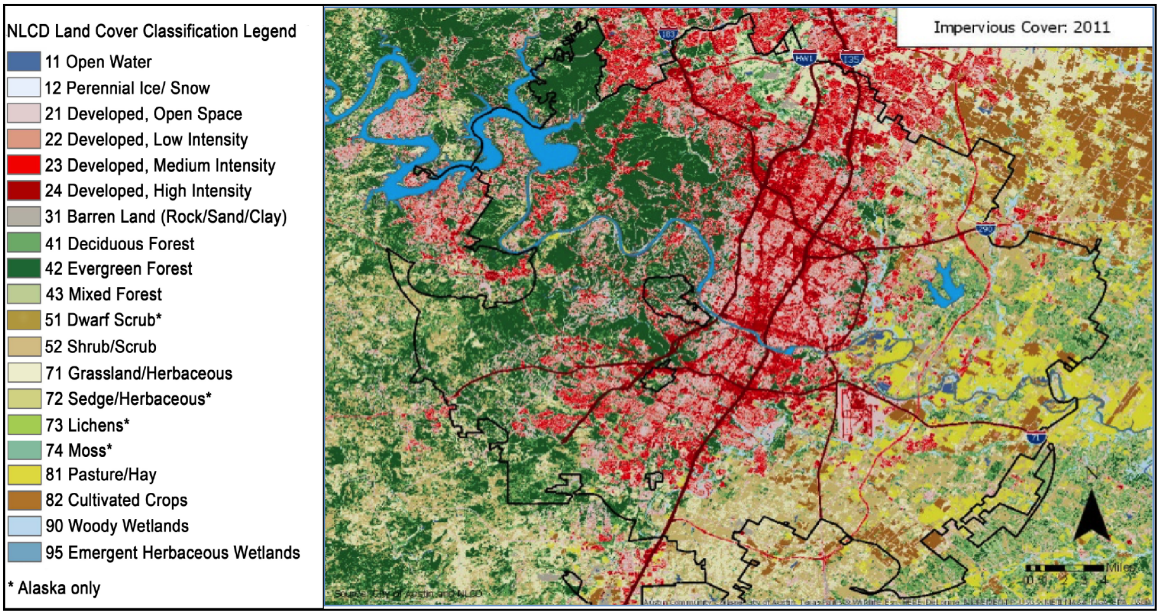

Figure 2. Impervious Cover over Austin in 2011[106]

Whiskey is for Drinking, Water is for Fighting

As the city grew in the early 20th century two conflicting and influential ideological perspectives emerged. One, driven by what urban theorists might deem an "urban growth machine",[107] prioritizes market expansion and economic success. As St.Edward's Professor William Swearingen noted in his book "Environmental City", it is and has been a force in Austin that steers development "*over* the natural environment, rather than *with* or *into* it.[108] Indeed, as the previous figures demonstrate, the central urban watersheds of Austin today are blanketed in impervious cover and we can observe its red hand extending further and further outward over time. Though it cannot be seen on these figures, the Promethean efforts of the 19th and early 20th century also galvanized the other equally influential cultural undercurrent. For many in Austin, promoters of city development put their very quality of life at stake. And, in order to preserve it, protection

[106] Land cover data was retrieved online from the National Land Cover Database while files on Austin's 2016 Extra Territorial Jurisdiction (ETJ) were retrieved through the city GIS database online.
[107] "Urban Growth Machine" is a theory of urban politics and economic development that finds urban growth to be an "areal expression" of a coalition of interest groups. A diverse set of interests finding commonality in the shared goal of increased land values and attracting new investments. (Molotch, 309)
[108] Swearingen, William Scott. "Environmental city: People, place, politics, and the meaning of modern Austin." *University of Texas Press,* 2010., 2

of the environment became a "central symbol" for saving a valued sense of place and way of life.[109]

This "imbroglio of nature and society",[110] as the Urban and Regional Studies Professor Andrew Karvonen described Austin, first manifested with the construction of the Austin Dam in 1893. Weighing in at sixty feet high and almost 1,200 feet across, it was at the time one of the largest dams in the world.[111] To build it a city bond was passed by popular vote with enough residents sold on an idea of transforming Austin: from a humble center of government and education to a modern bustling industrial city.[112] It marked the city's first foray into modernity but one that ended in utter failure[113] and when it collapsed seven years later there were long term ramifications extending beyond the immediate loss of life, property, and debt the city incurred. Moving forward, the allures of development would not be quite as compelling for many residents. Furthermore, Austin had now avoided the fate of becoming yet another industrialized city at the turn of the century. Most importantly, the Austin Dam was both a symbolic and physical catalyst that beget a city ethos. This ethos, which eschewed development and embraced a sense of place, has influenced how Austin has grown dramatically and is still relevant today.

In fact the city of Austin has become known for its efforts towards environmental protection. These efforts, which grew in strength in the 1970s and at its apex consisting of over one hundred and fifty active neighborhood and environmental groups, has over time successfully garnered commitments by the city to regulate urban development.[114] The 1976 Lake Austin Growth Management Plan for example, represents one of the first demonstrations of water quality planning in the United States.[115] Fast forward to today and water quality ordinances, regular water quality monitoring, and conservation land development practices, have codified and formalized a commitment to protecting the

[109] Karvonen, 48
[110] Karvonen, 88
[111] Hunt, Bruce. "The Rise and Fall of the Austin Dam." *The Department of History: The University of Texas.* Jul 2011. Web. Oct 2017. , 1
[112] Hunt, Bruce. "The Rise and Fall of the Austin Dam." *The Department of History: The University of Texas.* Jul 2011. Web. Oct 2017. , 1
[113] Sevcik, Edward. "Selling the Austin Dam: A Disastrous Experiment in Encouraging Growth". *The Southwestern Historical Quarterly.* Vol. 96, No. 2. Oct 1992. , 216
[114] Karvonen, 45
[115] Karvonen, 53

regions most cherished natural resources.[116] However, while the environmental values of many Austin residents have successfully been translated into government policy, a delicate balance remains between the forces behind the urban growth machine and those that would prefer to curtail it.

Austin, Stormwater Management, and Nature

The strong environmental ethic that arose in response to Austin's urban growth machine- reinforced out of a desire to protect Barton Springs- has since continued to identify with traditional notions of "nature" in the city. This perception is one that regards the inner city and the built human world as something not natural –as if removed from nature- and therefore not worthy of the same degree of environmental protection. Barton Springs for example, is advertised today as "an island of nature in an ocean of urban development",[117] and there is not a similar social movement to protect or restore Waller or Shoal creek as there was for the Springs. This despite the fact that Lady Bird Lake hosts over 2.6 million visitors a year,[118] and it is these waterways that flow into it. How Austin has managed stormwater up until this point has reflected this way of thinking, with traditional forms of infrastructure serving as physical and psychological divisions between people, their built environment, and the urban ecosystem they are a part of.

The current network of stormwater infrastructure in Austin consists of two hundred square miles of drainage, over 1,100 miles of drainage systems, and thousands of flood and water quality control measures.[119] It is a hybrid system consisting of natural and technological elements, of both green and gray infrastructure. Existing waterways within Austin have -much like other urban waterways across the United States- served as central components of this system: used for utilitarian purposes to transport wastewater, stormwater, or serve as expedient receptacles for the city's errant waste. Shoal and Waller Creek, for example, have been conscripted for just these purposes and as a result bear little resemblance to what they once were. This role that local waterways have been

[116] Karvonen, 53
[117] Karvonen, 35
[118] The Trail Foundation. "Butler Trail Map-Interactive". The Trail Foundation. N.d. Web. Aug 2017.
[119] Karvonen, 74

relegated to has been generally accepted as simply a symptom of urbanity. Acting as infrastructure for the city, it became not a question of whether the waterways could retain their natural state but rather how much should be spent to mitigate flooding, reduce public health risks, and keep them at least aesthetically out of mind.[120]

Using Austin's waterways in this manner was not only a result of simple convenience but also done for the sake of economic development and urban improvement. Because of a creek's low elevation, it was logical to locate sanitary sewer lines in their beds and for the same reason, stormwater networks were designed to directly discharge into creeks. With increasing amounts of impervious cover and therefore greater risks of flooding, it was thought necessary to also armor much of the banks of creeks, to prevent eroding, meandering, and therefore, property damage.[121] It is a way of planning that reflects a traditional approach towards stormwater management, one that separates urban residents from stormwater flows and reinforces widely held notions of where nature can and should be found in the city. The nature we value most in Austin, the kind that we seek to save, exists in specific places –in the Greenbelt, Barton Springs, or with the bats under Congress bridge- but not by our local urban waterways coursing through the inner city. Though there is not a broad citizen led effort to protect and restore these natural resources there are signs that the dynamic of Austin's relationship to its waterways and nature is changing.

The most recent iteration of watershed planning and management -the updated 2015 Watershed Protection Master Plan- serves as the current guide for the City of Austin's Watershed Protection Department (WPD) and marks a departure from past approaches to stormwater management. To do so, the plan discusses the department's evolution towards "smaller-scale, distributed green infrastructure structural solutions" and recommends establishing further partnerships with "private development and land owners".[122] As a test of this alternative service delivery model, beginning in 2015 the WPD embarked on a pilot project along the headwaters of Waller Creek. One intent of this project is to rehabilitate the impaired hydrological function of Waller Creek through

[120] Karvonen, 88
[121] Karvonen, 67
[122] Watershed Protection Department. "Watershed Protection Master Plan: FY 2015|2016." Watershed Protection Department. Austin, TX., 24

the application of decentralized green infrastructure: specifically, rain gardens and cisterns. Notably, the Rain Catcher Pilot Project is designed to not only meet hydrological goals (i.e. improve water quality and reduce erosion through increased filtration and infiltration), but also maximize community participation and raise public awareness about the value and benefits of healthy streams and stormwater stewardship.[123] The hope is that Austin residents along Waller Creek will recognize the value of these systems and consider installing rain gardens and cisterns where they live. However conveying the value and need for these environmental systems, as well as convincing citizens to adopt them, will be a great challenge for the city and could have significant implications for the future management of stormwater in Austin.[124]

[123] Scoggins, M., and Anna Gonzalez. Personal Communication. 1 Nov. 2016.
[124] Hollon, 2016.

Chapter 4: Diffusion of Innovations

Getting a new idea adopted, even when it has obvious advantages, is difficult.[125]
Everett M Rogers

Diffusion really includes three fairly distinct processes: presentation of the new culture element or elements to the society, acceptance by the society, and the integration of the accepted element or elements into the preexisting culture. [126]
Ralph Linton

Diffusion of Innovations: An Introduction

The City of Austin seeks to encourage the adoption of green stormwater infrastructure by its citizens yet relatively little research exists that analyzes residents' perceptions, values, and attitudes towards these systems and how this may influence their willingness to install them where they live. The success of this project will in many ways be determined by context: a product of the dynamic relationship that exists between Austinites, water, and their perceptions of nature. Whether Austin's historically strong environmental ethic and sense of place will translate to individual behavioral change in personal landscape preferences is the question that remains to be answered. While an individual's yard is often where one interacts most directly with their urban ecosystem, they are not blank slates and how yards are utilized is very much a complicated result of cultural influences, economics, personal values, and subjective preferences. In order to investigate what may be some of the challenges, barriers, and opportunities for the City of Austin and the Rain Catcher Pilot Project, a social science theory known as "Diffusion of Innovations" will serve as a guiding framework.

Diffusion of Innovations theory, from its early beginnings in rural American sociology,[127] was first formalized by communications theorist and sociologist E.M. Rogers in the 1960's and has since been applied in a variety of fields: from communications and marketing, to public health, education, criminal justice, and social

[125] Rogers, Everett M. "Diffusion of innovations". *Simon and Schuster*, 2010., 1
[126] Dearing, James W. "Applying diffusion of innovation theory to intervention development." *Research on social work practice* 19.5 (2009): 503-518., 503
[127] Valente, Thomas W., and Everett M. Rogers. "The origins and development of the diffusion of innovations paradigm as an example of scientific growth." *Science communication* 16.3 (1995): 242-273., 244

work.[128] Whether it be with regards to fertility-control methods, agricultural practices, or policy implementation,[129] the essential concept of the theory seeks to explain how an idea, behavior, technology, or product, -the "innovation"- is adopted throughout a population or social system -the "diffusion".[130] This diffusion can be articulated as a "flow or movement from a source to an adopter" by means of communication and influence.[131] Part of its utility and one reason for its common application today, is because it provides clarity on social change: specifically, how or why individuals are either encouraged or discouraged from adopting these innovations.[132]

In his book "Diffusion of Innovations" E.M. Rogers discusses the four main elements that contribute to a process of diffusion. This process can be generally outlined as: (1) an *innovation* (2) is *communicated through channel*s (3) over *time* (4) within members of a *social system.*[133] These elements and the process in which they occur are present in every diffusion research study and all diffusion campaigns or programs.[134] The rest of this chapter will provide an overview of these four important elements and conclude with its application to the Waller Creek Watershed pilot project.

The Four Elements of Diffusion

I. **The Innovation**

An innovation, in Everett Roger's words, is "an idea, practice, or object that is *perceived as new* by an individual or other unit of adoption."[135] This "newness" is not one determined by the passage of time simply but rather a perception of whether something *seems* new to the person. It does not necessarily involve the acquisition of new knowledge, as an individual may become aware of an innovation yet remain without

[128] Dearing, 504
[129] Wejnert, Barbara. "Integrating models of diffusion of innovations: A conceptual framework." *Annual review of sociology* 28. 2002., 298
[130] LaMorte, Wayne. "Diffusion of Innovation Theory". *Boston University School of Public Health.* April 2016. Web. 20 Aug 2017, 1
[131] Wejnert, 299
[132] LaMorte, 1
[133] Rogers, 11
[134] Rogers, 11
[135] Rogers, 11

an opinion or attitude towards it. Newness of an innovation therefore is expressed in terms of knowledge, persuasion, and a decision to adopt.[136]

An innovation will generally provide some degree of benefit to its potential adopters but its initial newness brings with it uncertainty. It is the reduction of this uncertainty that is the determining factor in the decision to adopt or reject the innovation. Once curious about its potential advantages it then becomes a process of information-seeking where typical questions asked by the individual might include: What is the innovation? How does it work? Why does it work? What are its advantages or disadvantages to me?[137] The potential benefit of a new innovation is the force that compels the person to seek out information.

Whether or not an innovation is seen to have potential benefits is determined by its characteristics. Though diffusion researchers offer an array of contributing qualities that play a role in an innovation's adoption,[138] it is widely accepted that five categories of "perceived attributes" largely explain the rate of adoption of an innovation.[139] In "Diffusion of Innovations", Rogers lists these categories as: relative advantage, compatibility, complexity, trialability, and observability.

1. *Relative Advantage:* to what extent an innovation is perceived by a potential adopter as better than the process, product, or idea that precedes it. This can be gauged in different ways: monetarily, in convenience, satisfaction, or in social prestige. The greater the perceived relative advantage the more likely (and more quickly) it is to be adopted.[140]
2. *Compatibility:* to what degree an innovation is perceived as consistent with existing values, past experiences, and needs of potential adopters. The values and norms of a social system play a significant role in this determination and will slow the rate of adoption if deemed incompatible.[141]

[136] Rogers, 12
[137] Rogers, 14
[138] Carlet, 21
[139] Rogers, 15
[140] Rogers, 15
[141] Rogers, 16

3. *Complexity:* the extent to which an innovation is perceived as difficult to understand and use. The less complicated an innovation is the more rapidly it will be adopted.[142]
4. *Trialability:* the degree to which an individual can experiment and become familiar with an innovation before the decision to adopt. If an innovation is trialable it can reduce the level of uncertainty and can lead to greater rates of adoption.[143]
5. *Observability:* the extent to which an innovation's results are apparent. The greater the visibility of an innovation the more likely people are to adopt it. Visibility encourages peer-to-peer discussions and incentivizes curiosity of the innovation.[144]

According to Rogers, those innovations that are viewed by individuals as having greater relative advantage, compatibility, trialability, and observability while also less complexity, are more likely to be adopted and more rapidly.[145] According to studies these five qualities are the most important observable and explanatory characteristics in the rate of adoption of innovations. More specifically, relative advantage, compatibility, and complexity have been found to be the most influential predictors for a variety of innovations while trialability and observability statistically less significant.[146]

II. **Communication Channels**

The essence of diffusion involves a particular type of communication, defined as: an exchange of information about a new idea from one individual to one or several others. Communication channels, the second component in Rogers' diffusion model, is the way in which this message travels from one individual to another and the nature of this exchange information relationship plays an influential role in the diffusion process. As Rogers points out, diffusion investigations have shown that the majority of individuals

[142] Rogers, 16
[143] Rogers, 16
[144] Rogers, 16
[145] Rogers, 16
[146] Yi, Mun Y., Kirk D. Fiedler, and Jae S. Park. "Understanding the role of individual innovativeness in the acceptance of IT-based innovations: Comparative analyses of models and measures." Decision Sciences 37.3. 2006. 393-426., 295

will not form an opinion of an innovation based solely on scientific or objective qualities but rather more so on a subjective evaluation conveyed to them from other adopters. This in turn means for example, that mass media channels may be an efficient and rapid way to raise awareness of an innovation but it is interpersonal channels that are more influential in the actual persuasion of an individual to accept or reject an innovation. Additionally, these interpersonal channels of communication can be more or less effective depending on certain personal and social characteristics of the individuals.

III. **Time**

Unlike a great deal of other behavioral science research, diffusion research incorporates the element of time which is considered in three distinct ways. In one sense it is a variable in the "*innovation-decision process":* a time ordered progression of the potential adoptee from initial awareness and knowledge of an innovation to their final decision to either adopt or reject the innovation. Rogers posits that there are five steps in this process: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. Organizing diffusion into these steps, or stages, may be an oversimplification of a complex reality but it can help in understanding the value of different communication channels and different types of information sought at each particular stage

Time is also important with regards to adoption rate and the "*innovativeness"* of an individual relative to others within a social system. Innovativeness, as Rogers defines it, is the degree to which an individual is early in adoption compared to other members of a system. Within social systems, individuals will have varying degrees of innovativeness such that diffusion researchers can associate them to five "adopter categories": (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards. Typically individuals within adopter categories will share similar characteristics where for example "late majority" adopters will often have relatively lower socioeconomic status, use less mass media, and will often adopt as a response to peer pressure or social

norms. Early adopters on the other hand will have more formal education, higher standards of living, and more favorable attitudes towards science, for example.[147]

Lastly, time is also considered with regards to the relative speed that an innovation is adopted by a social system. This rate of adoption follows a similar pattern such that when plotted on a cumulative frequency basis over time, the distribution will take the form of an S-shaped curve. Most innovations have this S-shaped form of adoption though the slope of the "S", or the speed and rate of adoption, will vary from innovation to innovation, or vary even for the same innovation but in different social systems.

IV. **Social System**

A social system, defined by Rogers as a set of interrelated units engaged in joint problem solving to achieve a common goal, can either facilitate or impede diffusion. A system will consist of individuals, informal groups, organizations, and/or subsystems, and its structure gives regularity to the human behavior of these social units. Importantly both the interpersonal networks and "*norms"* –defined as the established behavior patterns of members in a social system-[148] can have a greater influence on the diffusion of an innovation than the characteristics of an individual in a system. The norms of a system, whether on a national, community, religious, or organizational level, will indicate to individuals what behavior is expected. It is for this reason that the most innovative member of a system is frequently seen as "deviant" and that those individuals who are the most influential in advancing the spread of an innovation are ones who are well respected and at the center of interpersonal communication networks.[149] When a social system is "oriented to change" these latter individuals -or "opinion leaders"- will likewise be more innovative.[150] As Rogers notes: "diffusion is fundamentally a social process".[151] The following Figures 3 and 4 demonstrate the general process and stages an innovation will undergo through diffusion:

[147] Rogers, 22
[148] Rogers, 26
[149] Rogers, 27
[150] Rogers, 27
[151] Rogers, 34

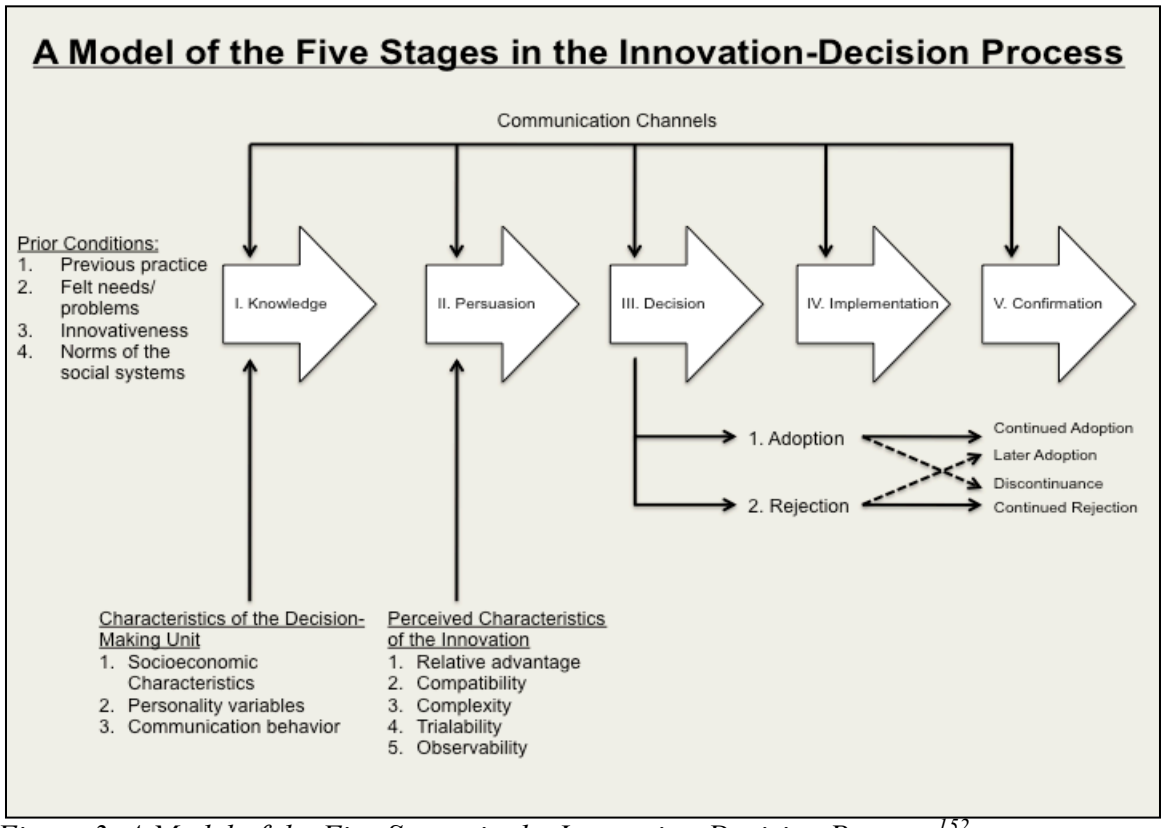

Figure 3. A Model of the Five Stages in the Innovation-Decision Process.[152]

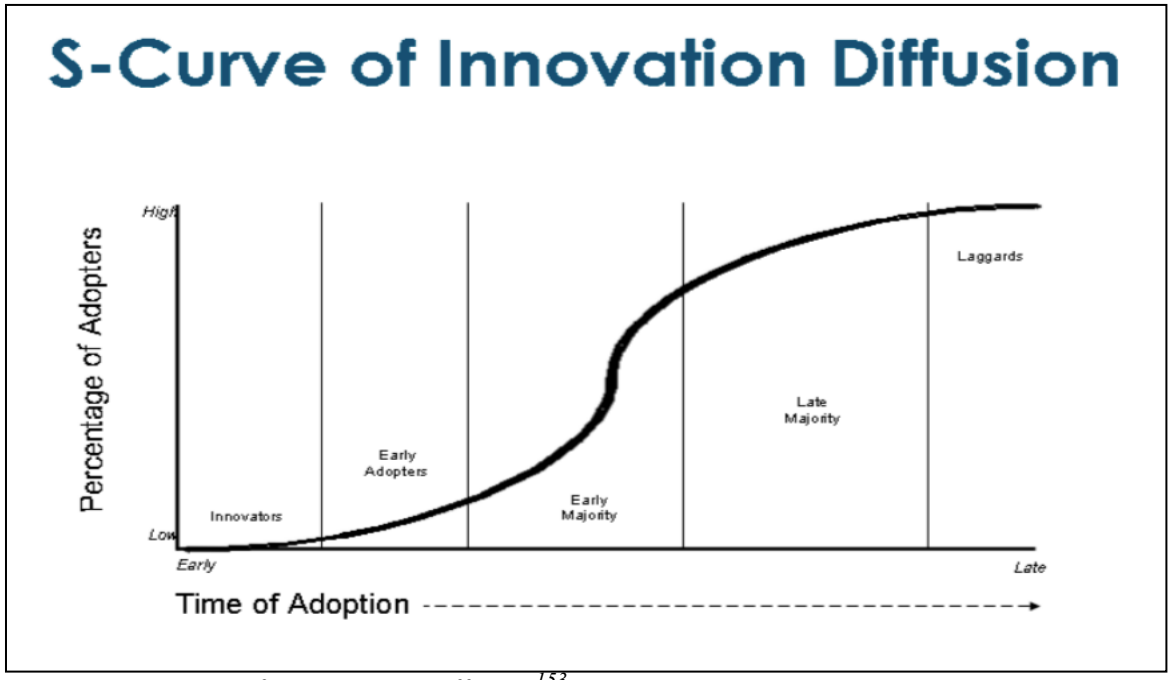

Figure 4. S-Curve of Innovation Diffusion[153]

[152] Rogers, 165

Chapter 5: Diffusion of Innovations and the Headwaters of Waller Creek Pilot Project

Introduction

The stated goal of the Watershed Protection Department's "Waller Creek Sub-3 Watershed" pilot project is to "improve water quality and quantity problems via small scale stormwater control measures in public and private properties in the headwaters of Waller Creek."[154] For this to be realized the WPD is testing an alternative "service delivery model", one that intends to maximize community participation in the installation and maintenance of these distributed Stormwater Control Measures (SCM) and one that also "emphasizes increased public awareness about the value and benefits of healthy streams and stormwater stewardship". A successful outcome of this pilot project therefore hinges upon engaging Austin residents and developing an understanding of their environmental values, how they use their yards currently, their perceptions of green stormwater infrastructure, and whether this will translate to a willingness to pay for and install rain gardens or cisterns. Diffusion of Innovations -a theory designed to explain social change- has been widely applied across a variety of disciplines and was used in this case to investigate and explore how the goals of the WPD can be achieved. The following sections outline how three of the main elements of the diffusion process –the innovation, time, and the social system- served as a framework to examine what may be the barriers and opportunities for the diffusion of these particular GSI innovations.

GSI as an Innovation

To best address the difficulties involved with the diffusion of green stormwater infrastructure –in this case rain gardens and cisterns- it is necessary to frame and understand GSI as a type of innovation. As previously discussed, an innovation is characterized as something new from the perspective of the adoptee. While the engineering or ecological concepts of GSI have been available for quite some time[155] it still has not been widely adopted as a technique to address stormwater management by

[153] Pinkett, Randal. "Bridging the Innovation Divide: An Agenda for Disseminating Technology Innovations in the Nonprofit Sector". *BCT Partners.* Nov 2015. Web. Sep 2017.
[154] Scoggins, M., and Anna Gonzalez. Personal Communication. 1 Nov. 2016.
[155] Mell, Ian C. "Green Infrastructure: concepts and planning." *FORUM Ejournal 8*:69-80. 2008., 70

US cities.[156] Furthermore, it is even more uncommon that strategies of stormwater management would involve local resident participation and buy-in to the extent that the Rain Catcher Pilot Project intends to.[157] Finally, though residential landscaping practices are increasingly informed by more sustainable practices –i.e. "naturescaping", Xeriscaping, or Wildlife Habitat Certifications- consideration of stormwater with regards to personal yard management is still a relative novelty.[158] Indeed, the implementation of decentralized green stormwater infrastructure to this degree represents a paradigm shift in both stormwater and yard management practices.[159] With these considerations in mind, these GSI systems and the manner in which they will be implemented can be considered innovations. To gauge the likelihood that rain gardens and cisterns will be adopted or conversely what may be the barriers preventing their adoption, we can examine the characteristics of these innovations as perceived by potential adopters in Austin.

As stated earlier, an innovation's characteristics can be grouped into five categories: relative advantage, compatibility, complexity, trialability, and observability. Those innovations that are perceived by potential adoptees as having less complexity but greater relative advantage, compatibility, trailability and observability, will have a better likelihood of adoption. More specifically, relative advantage, compatibility, and complexity will have the most significant influence over adoption. To investigate the perceived attributes of rain gardens and cisterns and how they may contribute to an individuals' willingness to adopt these systems the study sought to answer the research question:

- Is there a relationship between the perceived characteristics of relative advantage, complexity, and compatibility of rain gardens and/or cisterns and the willingness of individuals to adopt these systems?

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[156] Olorunkiya, Joshua, Elizabeth Fassman, and Suzanne Wilkinson. 2012. "Risk: A Fundamental Barrier to the Implementation of Low Impact Design Infrastructure for Urban Stormwater Control." *Journal of Sustainable Development* no. 5 (9):27-41., 28
[157] Porse, 40
[158] Staff. "Six Standout Landscaping Trends for 2016". *American Nurseryman.* Apr 2016. Web. Sep 2017, 1
[159] Roy, Allison, Seth Wenger, Tim Fletcher, Christopher Walsh, et al. "Impediments and Solutions to Sustainable, Watershed-Scale Urban Stormwater Management: Lessons from Australia and the United States." *Environmental Management* no. 42 (2):344-359. 2008., 345

Based on a review of the literature three hypotheses were made with regards to the effect that these characteristics may have on the potential adoption of rain gardens and cisterns:

H1. Low perceived relative advantage of rain gardens and cisterns (i.e. high cost, high maintenance, little perceived environmental benefits) will have a negative influence on willingness to adopt these systems.

H2. Low perceived compatibility of rain gardens and cisterns (i.e. limited space, aesthetics) will have a negative influence on willingness to adopt these systems.

H3. High perceived complexity (i.e. need help with installation, not enough time) of rain gardens and cisterns will have a negative influence on willingness to adopt these systems.

GSI and Time

In addition to the innovation itself, another of the four main elements of diffusion concerns time. As stated earlier, the variable of time is considered in three ways: in the innovation-decision process, with regards to innovativeness and adopter categories, and in terms of the rate of adoption. By addressing these elements diffusion research can provide a basis for understanding human behavioral change over time and aid in the introduction of an innovation.[160] Surveys as a tool in particular, can act as a yard-stick device to quantitatively measure the progression of an innovation-decision process, the innovativeness of potential adoptees within a social system, and to what extent an innovation has been adopted at a particular moment in time.

I. The Innovation-Decision Process: Awareness-Knowledge

As Rogers stated: "the innovation-decision process is essentially an information-seeking and information-processing activity in which an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation."[161] This is a process of choices and actions taking place over time as an individual or system evaluates an innovation.[162] The first stage of this diffusion process is "awareness-knowledge" of

[160] Rogers, 195
[161] Rogers, 172
[162] Rogers, 168

the innovation and it is only after this stage that an individual will then begin to seek "how-to knowledge" (or information necessary to use an innovation), before potentially moving onto the later stages of persuasion, decision, implementation, and confirmation. Diffusion research elaborates further, demonstrating that initial awareness-knowledge *may* motivate an individual to seek how-to knowledge, especially if the innovation is relevant to the individuals needs, attitudes, and beliefs.[163] As Rogers notes, "an individual may know about a new idea but not regard it as relevant to his or her situation or as potentially useful."[164]

With regards to the innovation-decision process and rain gardens and cisterns in Austin, it is likely that the process for many is in its infancy, given that these specific GSI systems have only been promoted by the city for a relatively short period of time. Furthermore, there may be an expressed need for more information due to not only a general lack of awareness-knowledge but also because of the environmental ethic that exists in Austin. To investigate existing knowledge-awareness of these innovations and whether this awareness will translate into information seeking this study sought to answer the research question:

- What is the knowledge-awareness of these innovations in the study area and is there an expressed need for more information?

Based on diffusion of innovation literature the following hypothesis were made:

H4. "Awareness-knowledge" of rain gardens and cisterns will be low relative to total survey responses.

H5. Greater expressed concern for the environment will be a motivating factor and have a positive effect on an expressed request for more information.

II. Adopter Categories and Innovativeness

When an individual will adopt an innovation relative to others is contingent on his/her degree of *innovativeness.* Innovativeness is a relative dimension, such that

[163] Hassinger, Edward. "Stages in the Adoption Process." *Rural Sociology.* 1959. RS(N). 24:52-53. , 52
[164] Rogers, 174

individuals will have more or less of this variable than others in a social system.[165] In other words the more innovative the person is the more likely to adopt an innovation and sooner. Because of this individuals can be classified into adopter categories, where each category represents individuals with a similar degree of innovativeness.[166] Diffusion research has revealed important distinctions between these categories in terms of socioeconomic status, personality variables, and communication behavior.

Three significant socioeconomic characteristics that influence innovativeness and therefore adoption, are: age, formal education, and income. Supported by a great amount of diffusion studies on variables related to innovativeness, early adopters will tend to have both more years of formal education and a greater amounts of wealth.[167] On the other hand, there has been inconsistent evidence about the relationship between age and innovativeness. Many studies demonstrate age as having no relationship, while others found early adopters are younger, and others, older. By developing an understanding of individuals based on these characteristics more effective strategies of communication and messaging can be utilized for each unique audience to enable greater adoption of specific innovations.[168] For this reason this study sought to answer the research question:

- What significance does age, income, and education have on the adoption of rain gardens and cisterns?

Based on a review of the literature the following hypothesis were made:

H6. Innovators and early adopters –those that have or said they'd be willing to install these systems- will have higher levels of formal education and income.

H7. Greater levels of formal education and income will be positively related to the amount of individuals who would be willing to adopt rain gardens and cisterns.

H8. Age will not be a factor in an expressed willingness to adopt rain gardens and cisterns.

[165] Rogers, 280
[166] Rogers, 267
[167] Rogers, 288
[168] Rogers, 299

H9. Age will not be a factor for individuals who have already adopted rain gardens and cisterns.

GSI and the Social System

Diffusion research demonstrates that an individuals' innovativeness and willingness to adopt is influenced not only by their own personal characteristics but also by the nature of the social system that they are a member of. [169] Often a system's *norms* can even be the main explanation for a particular rate of adoption. Returning again to the idea of *compatibility,* if an innovation does not align with widely held cultural values its adoption will be delayed if not prevented entirely.[170] In addition to cultural values, compatibility is also influenced by previously adopted ideas. These ideas –i.e. current practices- are the foundation and standard against which an innovation can be interpreted.[171]

For the purposes of the Rain Catcher Pilot project we can examine people's yards (and their use of them) to derive a better understanding of these prevailing influences and how they may be a factor in the adoption of rain gardens and cisterns. As previously discussed, residential yards and the lawns often found on them, express values that are deeply influenced by cultural norms. A great deal of research has demonstrated that not only do these norms influence personal preferences when it comes to yard management but that they can also impact people's perception towards and subsequent decision to adopt more ecologically friendly design choices.[172] By investigating in what way residents value and prioritize ecosystem services –either provisioning, regulating, supporting, or cultural- in the management of their yards, we are providing a valuable perspective on these social norms, cultural values, and previously held ideas that will influence decisions to adopt. To do so this study sought to answer the research question:

- What is the prevailing social norm in terms of yard management in the study area and is it compatible with rain garden and cistern innovations?

[169] Rogers, 26
[170] Rogers, 241
[171] Rogers, 243
[172]Nassauer, Joan Iverson, Zhifang Wang, and Erik Dayrell. "What will the neighbors think? Cultural norms and ecological design." *Landscape and Urban Planning* 92.3 (2009): 282-292., 283

Based on the literature review the following hypothesis was made:

H10. Survey respondents will prioritize cultural ecosystem services (e.g. aesthetics) as opposed to provisioning, regulating, or supporting ecosystem services (e.g. biodiversity)

Chapter 6: Methodology

Project Goals and Study Area

The stated objectives of the WPD's pilot project, Rain Catcher, are: one, to increase filtration and infiltration, reduce erosion and flooding, and raise public awareness about the value and benefits of healthy streams and stormwater stewardship and two, to pilot an alternative service delivery model towards achieving the WPD Master Plan water quality goal of protecting and improving Austin's waterways. This service delivery model will maximize community participation in the installation and maintenance of distributed small-scale GSI on public and private property to capture and treat runoff at its source.[173] As a means to achieve this two early goals of the WPD are:

- By the end of Fiscal Year 2020, asses the degree of adoption of cisterns and rain gardens in eligible residential and commercial private parcels through a targeted outreach platform that provides technical assistance, a seamless process to apply, and an enhanced incentive/rebate system that leverages resources from Austin Water Utility and other stakeholders.
- By the end of Fiscal Year 2020, complete an assessment report on market penetration and recommendations for optimizing community participation. [174]

This Pilot Project's location -the headwaters of Waller Creek- was chosen for a combination of factors:

- The availability of flow baseline data to monitor changes over time in Waller Creek (i.e. baseline flow, erosional flows, peak flows) due to USGS gauge.
- The study area is currently ranked #7 of the worst twenty watersheds in terms of water quality and erosion and has therefore been prioritized for capital improvement projects.
- Only 3.45% of total area remains undeveloped, therefore net changes in impervious cover are unlikely.
- It was determined that the effects of SCMs could be detected given the relatively small drainage area that makes up the pilot area.. [175]

[173] Scoggins, M., and Anna Gonzalez. Personal Communication. 1 Nov. 2016.
[174] Scoggins, M., and Anna Gonzalez. Personal Communication. 1 Nov. 2016.

The following Figures 4 and 5 demonstrate the location of study area relative to the city of Austin and the land use within the watershed, respectively.[176]

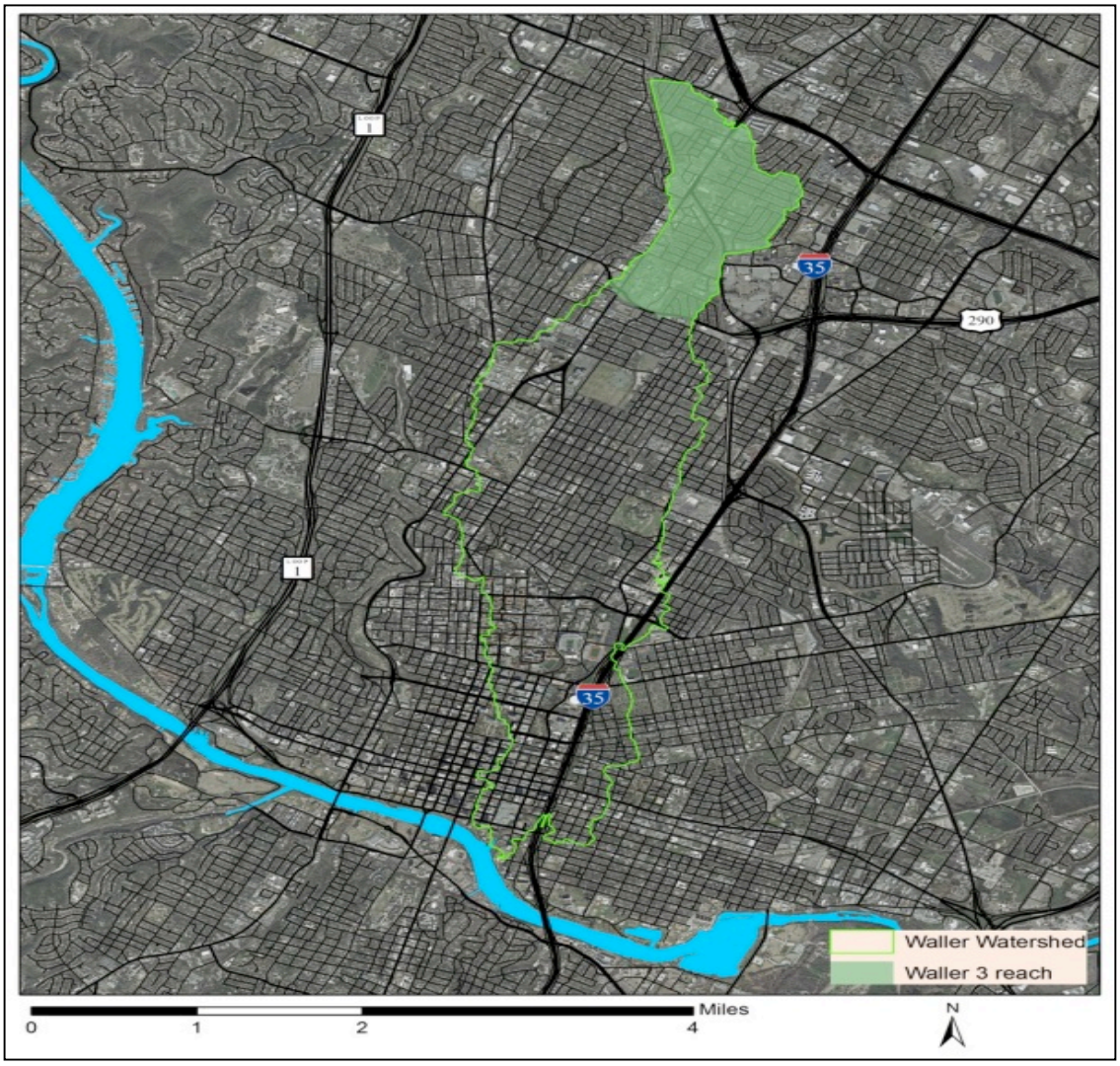


Figure 5. Waller Creek Watershed and Study Area (Waller 3 Reach)

[175] Scoggins, M., and Anna Gonzalez. Personal Communication. 1 Nov. 2016.
[176] Scoggins, M., Anna Gonzalez and Amy Grossman. Personal Communication. 1 Nov. 2017.

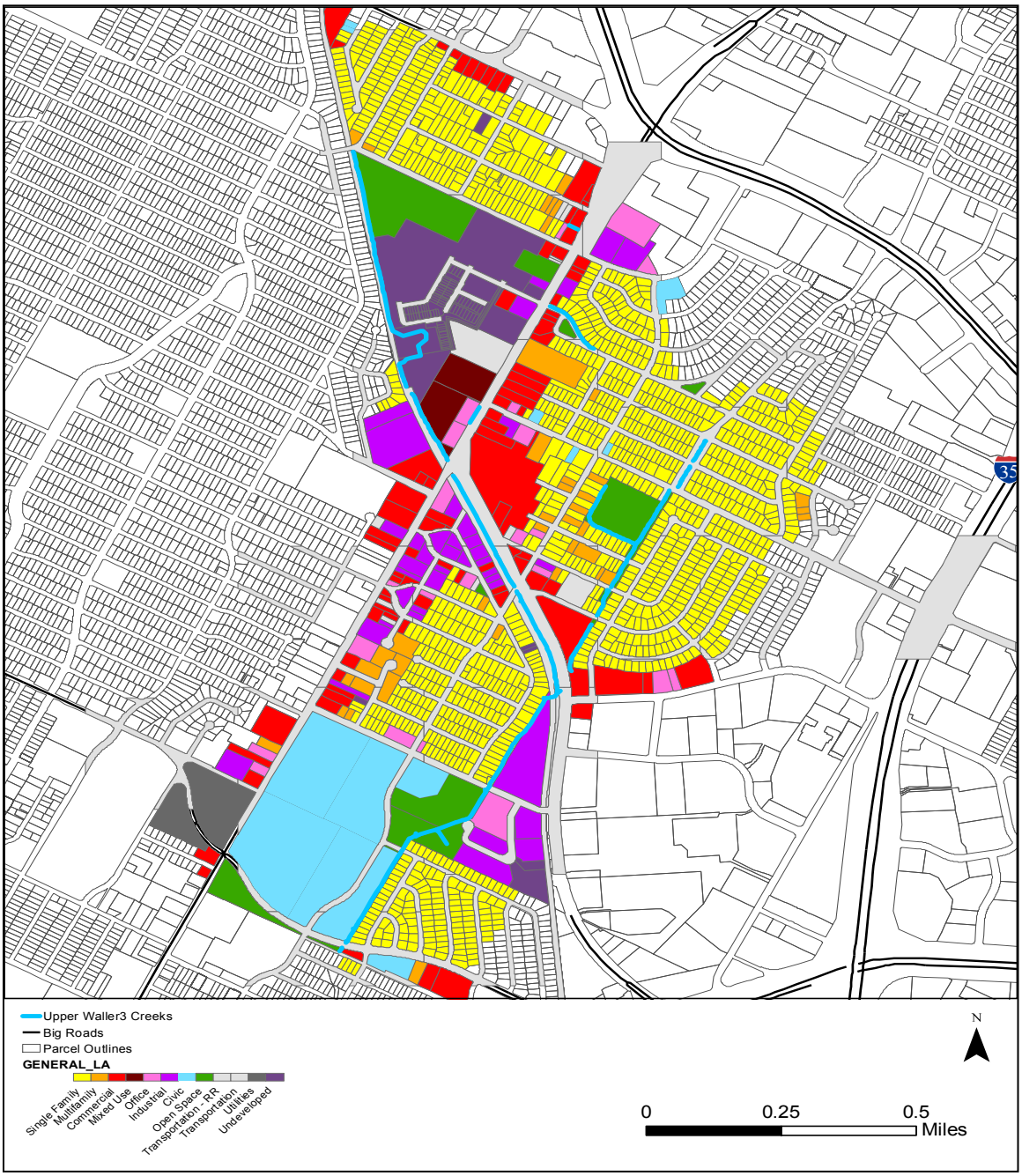


Figure 6. 2016 Study Area Land Use Map

Survey

To apply the theory of Diffusion of Innovations for the Rain Catcher Pilot Project, I conducted a variance-type of investigation. Variance research is the most common type of diffusion investigation and is a quantitative form of data gathering and analysis that assigns numerical values to behaviors. Surveys are commonly used in variance-type research and are useful tools to reveal and explain behavior and perceptions towards innovations at specific points in time.[177]

I developed the survey using both rating and Likert[178] scale questions to measure the four main areas of interest: perceptions of these innovations, knowledge-awareness of these innovations, innovativeness among potential adopters, and social norms. The final section of the survey contained close-ended questions seeking demographic and socio-economic information. In order to be easily understood by survey takers I designed questions without the use of jargon or abbreviations. Also, all identifying information was submitted separately from survey responses to ensure anonymity. Additionally, I subjected the survey to a revision process with WPD staff and pretested it with volunteers to ensure quality of understanding.

To encourage more responses I invited participants to participate in a gift card raffle to be conducted at the conclusion of the study. To also maximize the total amount and diversity of responses and respondents, I and WPD staff engaged potential survey takers in the three neighborhoods of Highland, Crestview, and Skyview in four ways:

1. *Postcard:* A postcard providing information about the survey was mailed to 1,648 single-family addresses (obtained through the Travis County Appraisal District online and provided by WPD staff). Of the 1,648 addresses provided, 30 were listed as "Null" and 79 did not arrive at the address listed. Therefore an estimated 1,548 addresses received postcards. Individuals who received the postcard were asked to follow a link to the survey online hosted by Qualtrics, a survey software provided by the University of Texas. This postcard can be found in Appendix B.

[177] Rogers, 196
[178] Likert scale is a five, seven, or nine point scale used to measure respondents' agreement with particular statements.

2. *Nextdoor:* Two notifications were sent out to the three neighborhoods via Nextdoor, a private social network accessed through a computer or phone application, associated with unique neighborhoods, and used by individuals in Austin. Each Nexdoor message included a link to the survey online. Messages used in Nextdoor can be found in Appendix B.
3. *Canvassing*: The researcher and a member of the WPD staff canvassed the three neighborhoods to recruit volunteers to take a paper version of the survey. These responses were later manually included into total results using Qualtrics software by the researcher.
4. *Neighborhood Associations:* The researcher and members of the WPD staff attended Highland and Crestview neighborhood meetings to discuss the WLR3 project and notify members of the survey. Additionally, notifications of the survey were posted on neighborhood Facebook pages. The same message used for Nextdoor was used to post on Facebook.

After conducting the survey over the course of three months, it was concluded on September 1st, 2017. In total, there were 201 respondents: individuals who either submitted paper copies of the survey or accessed the survey online. Completion rates varied and of the respondents, 96 of the surveys were entirely completed and 69 completed at least 90 percent of the survey. The following Figure 7 represents the distribution of surveys according to their degree of completion:

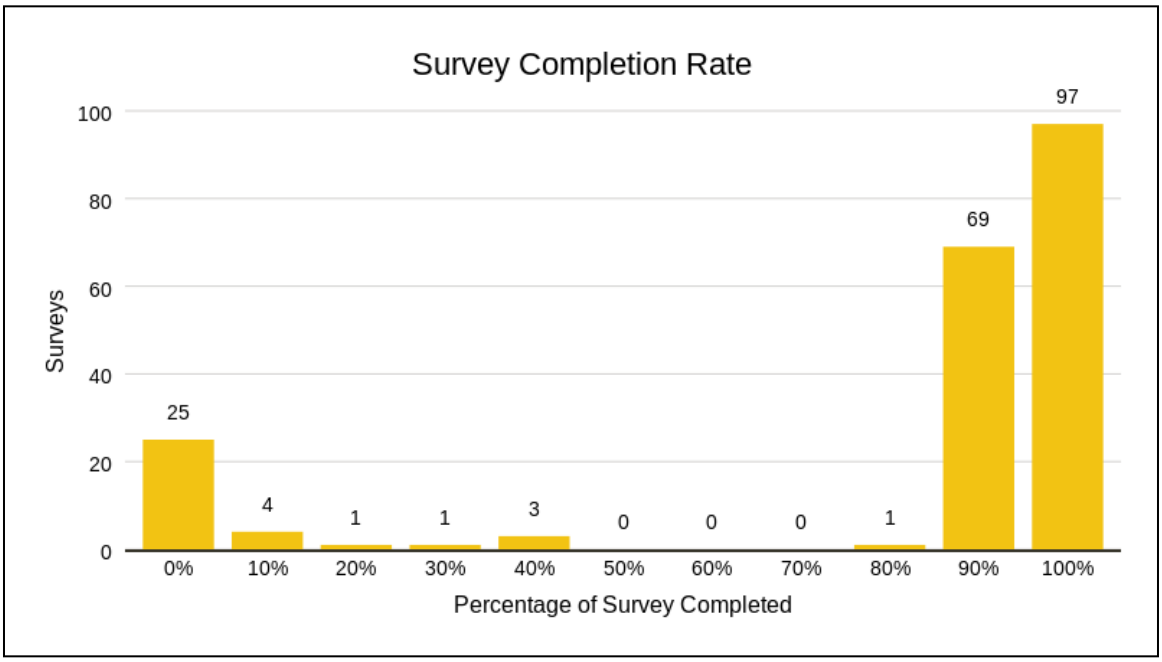


Figure 7. Survey Completion Rate

Chapter 7: Study Area and Survey Statistics

Study Area Summary

The study area consists of 639 total acres of which 46% is covered by impervious surfaces.[179] This sub-watershed encompasses the primarily residential neighborhoods of Highland, Skyview, and Crestview. Approximately 6,762 individuals live in these neighborhoods, where 56% own their places of residence and 44% rent. This rent to own ratio within the watershed is greater than that of the city at large, which is about a 50% to 50% split between renters and owners. The age distribution of the sub-watershed matches the citywide age distribution fairly well. There is a higher percentage of Anglo residents within the study area and a similar percentage of Hispanic individuals compared to the city in general.[180]

Survey Summary

Total responses from the survey represent about 2.5% of the study area population.[181] The overall demographic picture of survey participants was: homeowners, well educated, middle aged, English speaking, and long time residents of Austin. More specifically, the average age was 47 and the median 45, with 57% of individuals falling between the ages of 31 and 50 and only 15, or 9%, of respondents between the age of 21 and 31 (the survey was not conducted with anyone less than 21 years of age). About 94% of respondents listed English as the primary language spoken at home with 5% stating Spanish was spoken instead. 83% of survey respondents reported they had either a four year college or post graduate degree. Additionally, respondents predominantly owned their residences, with only 14, or 8%, of survey takers stating that they rent instead. A majority, 78%, have lived in Austin for more than 10 years, though only 44%, or 73 respondents, have also lived at their current residence for the same amount of time. Relative to the city at large, the survey over-represents: homeowners, people over the age of 35, educated people with college or post-graduate degrees, and individuals making over $100 thousand annually.[182] The following Tables and Figures represent these data.

[179] Scoggins, M., and Anna Gonzalez. Personal Communication. 1 Nov. 2016.
[180] Herrington, Chris. Personal Communication. 14 Oct. 2017.
[181] Grossman, Amy and Chris Harrington. Personal Communication. 14 Oct. 2017.
[182] Grossman, Amy and Chris Harrington. Personal Communication. 14 Oct. 2017.

Total Populations of Survey, Study Area, and City of Austin			
	Survey	Study Area	City of Austin
Number of People	176	6,762	937,065

Table 1. Total Populations of Survey, Study Area, and City of Austin[183]

Percentage of People who Rent vs. Own: Survey, Study Area, City of Austin			
	Survey	Study Area	City of Austin
People that Rent	8.43	43.62	50.83
People that Own	91.57	56.38	49.17

Table 2. Percentage of People who Rent vs. Own: Survey, Study Area, City of Austin[184]

Level of Education as Percentage of Total Population		
	Survey	Austin
Junior high school or less (1rst to 8th grade)	0.60	6.60
Some high school	0.60	5.90
Earned a high school diploma or GED	1.80	16.20
Some college or technical school (no degree)	10.18	19.60
Two year college degree	2.99	5.00
Four year college degree	43.11	29.80
Post graduate degree (Ph.D., M.D., etc.)	40.72	16.90

Table 3. Level of Education as Percentage of Total Population[185]

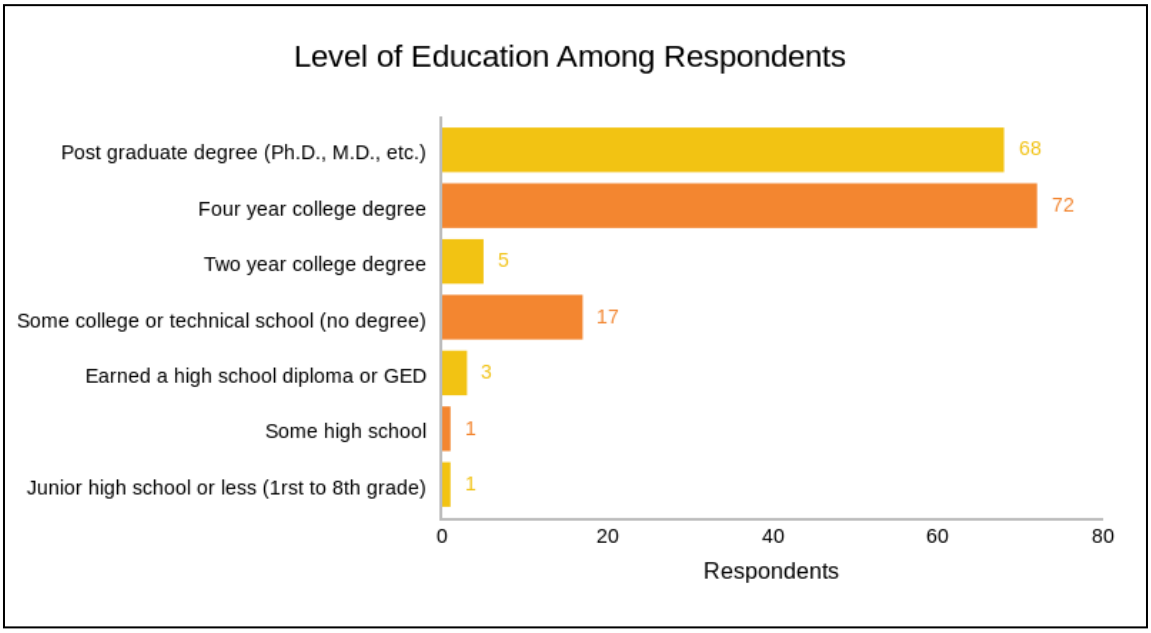


Figure 9. Level of Education Among Respondents

[183] Grossman, Amy and Chris Harrington. Personal Communication. 14 Oct. 2017.
[184] Grossman, Amy and Chris Harrington. Personal Communication. 14 Oct. 2017.
[185] Grossman, Amy and Chris Harrington. Personal Communication. 14 Oct. 2017.

Age Groups as a Percentage of Total Population: Survey, Study Area, City of Austin			
	Survey	Study Area	City of Austin
Under 5 Years	0	6.09	6.8
Age 5 to 9 Years	0	4.60	6.2
10 to 14 Years	0	3.43	5.8
15 to 17 Years	0	2.01	
18 to 19 Years	0	2.01	6.2
20 to 24 Years	0	8.57	9.2
25 to 34 Years	20.12	23.97	21.4
35 to 44 Years	29.27	18.51	15
45 to 54 Years	21.34	13.03	12.2
55 to 59 Years	9.15	5.65	5.2
60 to 64 Years	6.1	3.78	4.5
65 to 74 Years	10.98	4.32	4.5
75 to 84 Years	3.05	3.36	2.1
85 Years and Over	0	0.68	0.9

Table 3. Age Groups as a Percentage of Total Population: Survey, Study Area, City of Austin[186]

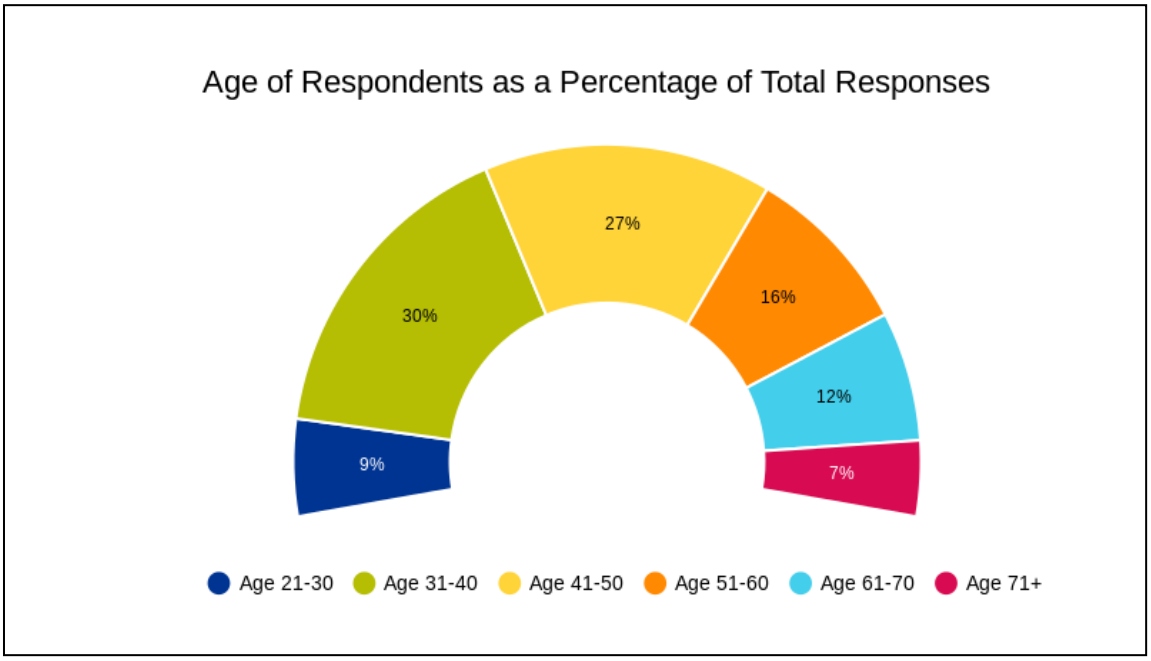


Figure 8. Age of Respondents as a Percentage of Total Responses

[186] Grossman, Amy and Chris Harrington. Personal Communication. 14 Oct. 2017.

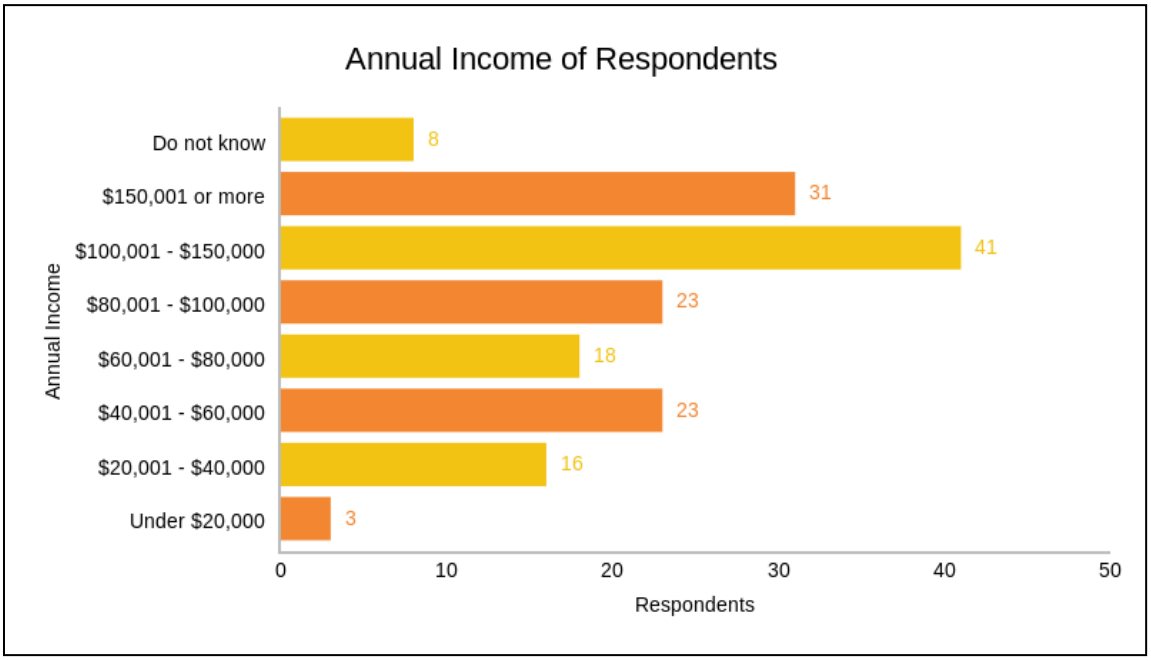


Figure 10. Annual Income of Respondents

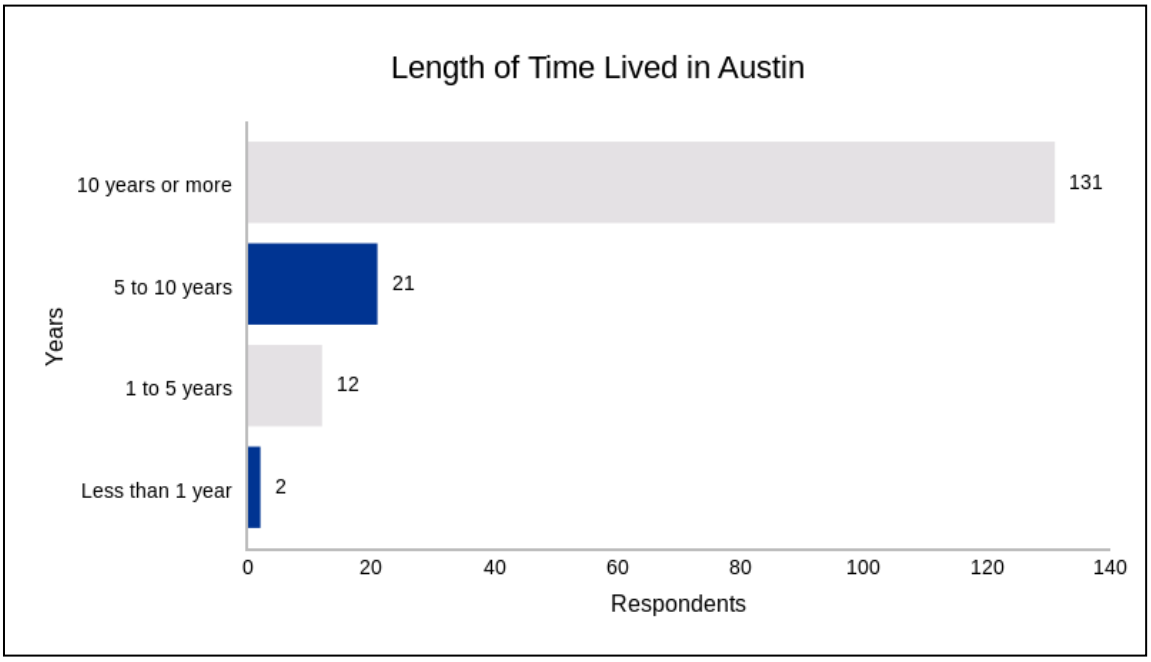


Figure 11. Length of Time Lived in Austin by Respondents

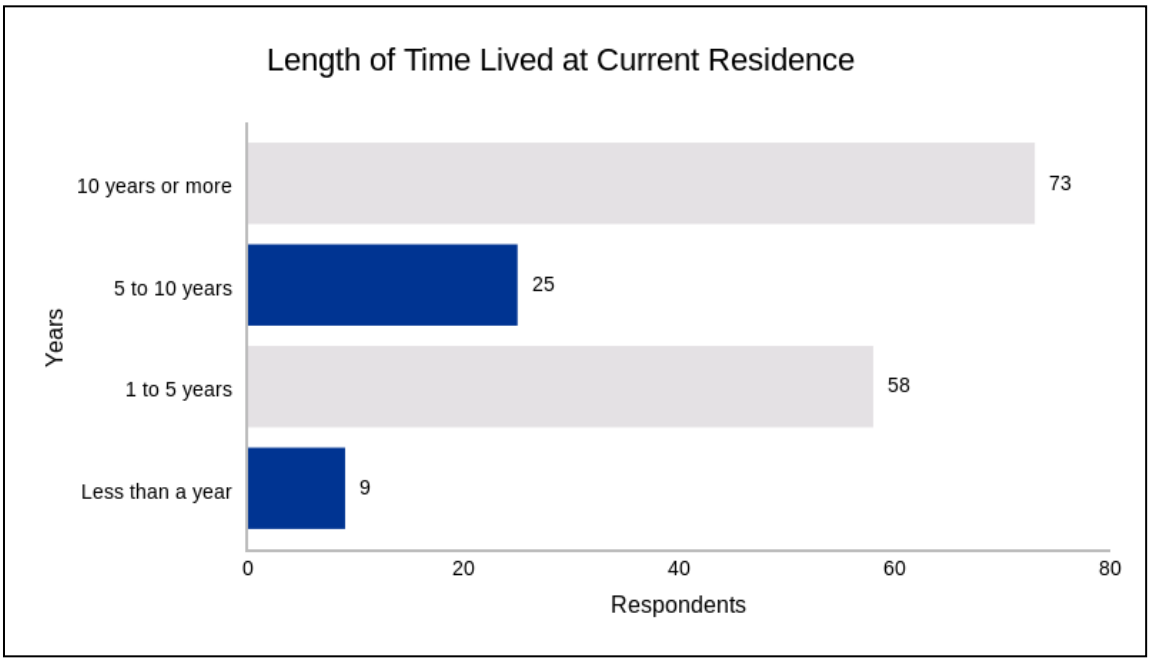


Figure 12. Length of Time Lived at Current Residence

Chapter 8: Survey Results and Discussion

I have a rather natural rain garden. It's my backyard. I'll explain. When our neighborhood was built the yards were sloped to allow water to run down hill, so my yard would allow water to flow into the yard behind which is downhill and then into the street and so on. My neighbor has built his yard up to the point that all the water that lands on my yard, and the yard next door, pools in my yard. So, we are a rain garden.
-Anonymous Survey Response on Rain Gardens

Nothing in my yard gets regular supplemental water. Survival of the fittest. If it were economical to use rainwater in the house I'd be interested.
-Anonymous Survey Response on Cisterns

GSI as an Innovation (Hypothesis 1-3)

To gauge the perceived characteristics of relative advantage, compatibility, and complexity of these innovations, two questions were included in the survey for participants. These questions asked respondents to rate what would be the most important things to consider when deciding on whether to install a rain garden or cistern. The "considerations" included: "limited space, maintenance, aesthetics, environmental benefits, cost, reduction in monthly water bill, help with installation, permission from landlord, and other". These questions can be found in Appendix D, Section A of the survey. To derive a more specific picture of these "considerations" in terms of adopter categories the responses were then broken down into three groups of individuals: those who had installed either rain gardens or cisterns (the innovators), those that would be willing to install both but hadn't (early adopters), and those that said they would never install either (late majority or laggards). To provide further perspective on the innovations, three additional questions were asked: one, how much would respondents be willing to pay for each GSI, two, was the respondent aware that the City of Austin offers rebates for these GSI systems, and three, how much do respondents spend on yard maintenance and yard care in a year. Finally, a question was included to determine what, if any, incentives could the City provide to encourage greater adoption.

H1. Low perceived relative advantage of rain gardens and cisterns (i.e. high cost, high maintenance, little environmental benefits) will have a negative influence on willingness to adopt these systems.

H2. Low perceived compatibility of rain gardens and cisterns (i.e. limited space, aesthetics) will have a negative influence on willingness to adopt these systems.

H3. High perceived complexity (i.e. need help with installation, not enough time) of rain gardens and cisterns will have a negative influence on willingness to adopt these systems.

I. GSI as an Innovation Discussion

Would not do again. Cistern does not collect enough water to make a difference. You don't need it when it rains and in the summer, you use it up rapidly so it sits. Also collects debris in the bottom over time.
-Anonymous Survey Response on Cisterns

What is the matter with my large and grassy yard? Why install something to replace it?
-Anonymous Survey Response on Rain Gardens

Overall a majority of survey respondents expressed a willingness to install rain gardens (142 individuals) and cisterns (119 individuals) and a minority said they would never install either rain gardens or cisterns (27 and 26 individuals respectively). While this does indicate that the innovations' characteristics are perceived by residents to have potential benefits that can translate to adoption, this also may represent a bias in survey sampling: either in under-coverage (when some members of the sample population are under-represented) or due to voluntary response bias (when sample members are self-selected volunteers).[187] For example, because the survey represented wealthier, more educated residents relative to the city at large it may reflect the perceptions of this demographic in particular.

In terms of current adoption rate, very few people had already installed rain gardens (6 individuals) and more responded that they had installed cisterns (25

[187] Easton, Valerie and John McColl. "AP Statistics Tutorial: Bias in Survey Sampling". *Statistics Glossary.* Sep 1997. Web. Oct 2017

individuals). The difference between the current adoption rate of the two GSI could also explain the difference in willingness to install either rain gardens or cisterns (less people are willing to install cisterns because they already have them). The overall low adoption rate demonstrates that it is very early on in the diffusion process of these innovations. Additionally, though a description of cisterns was provided within the survey, based on anecdotal evidence from canvassing it is probable that these individuals had installed rain barrels rather than cisterns (cisterns are quite larger than rain barrels: around 500 gallons versus 55 gallons). The following Figure 13 represents overall willingness to install rain gardens and cisterns among survey respondents.

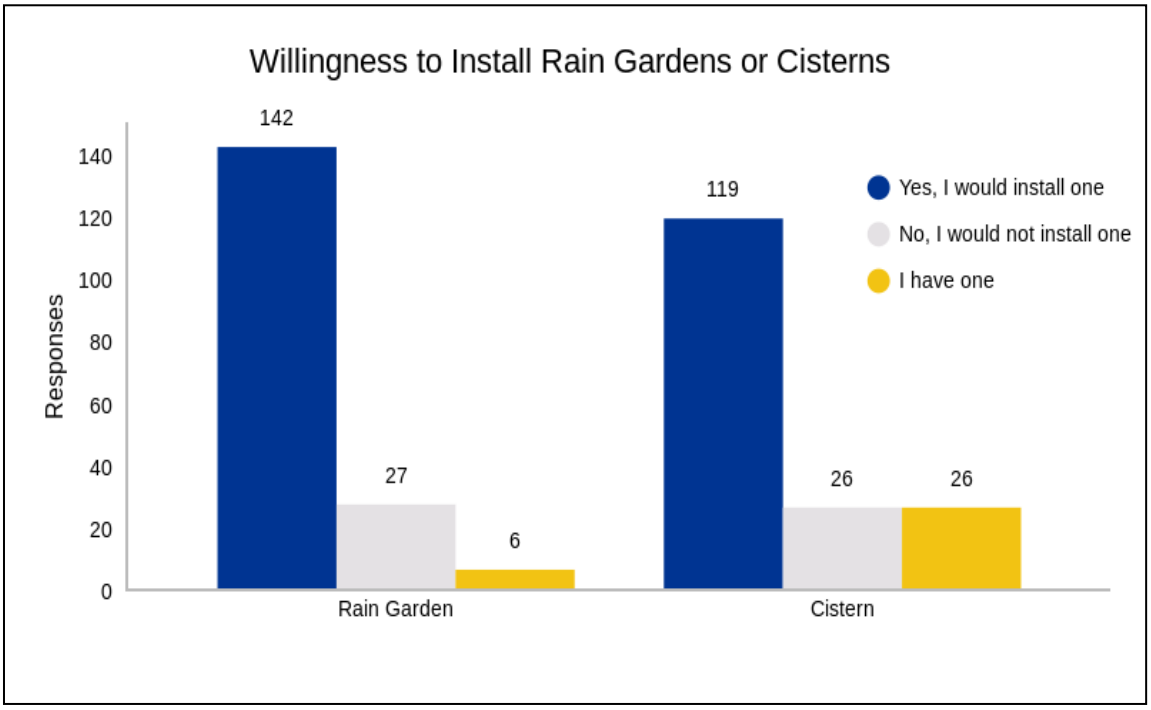


Figure 13. Willingness to Install Rain Gardens or Cisterns

In terms of how much respondents would be willing to pay for these innovations, a majority –around 90%- would be not willing to spend more than $500 on either cisterns or rain gardens. More specifically, only 10% and about 7% of respondents said they would spend $500 or more on a cistern or rain garden, respectively. In contrast, 34% of responses stated they currently spend over $500 on their yards annually. One additional factor to consider in terms of costs: a majority of survey takers -67%- were not aware that

the City offered financial rebates. The following Figure 14 represents a comparison of how much individuals are willing to spend on each GSI versus how much they spend on their yards annually.

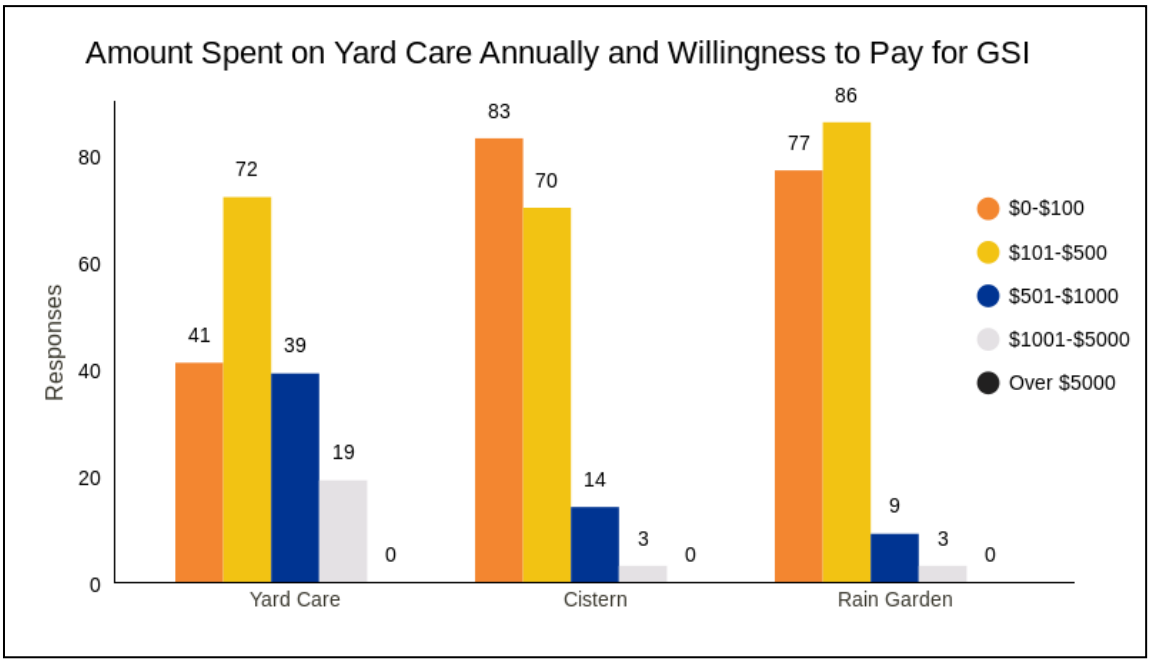


Figure 14. Amount Spent on Yard Care Annually and Willingness to Pay for GSI

In the survey, respondents were asked to rank their top three "considerations" (or perceived characteristics) with regards to both rain gardens and cisterns. Overall, for both types of GSI "cost" and "maintenance" were selected most often as important "considerations", in that order. Additionally "help with installation" was the third most important consideration though for rain gardens, "aesthetics" was selected as many times as "help with installation". Also in both cases, "environmental benefits" was not a perceived relative advantage that was valued as much as the other "considerations". These responses were mirrored in the answers individuals provided to the question on preferences of City incentives: "financial assistance through a rebate" was ranked the highest by a wide margin, followed by "consultation with a professional landscape designer" and both "a decrease in your monthly drainage charge" and "physical assistance with maintenance or installation". The following Table 1 and Table 2 show these results.

Top Three Considerations for Survey Respondents			
	#1	#2	#3
Rain Gardens	Cost	Maintenance	• Help with Installation • Aesthetics
Cisterns	Cost	Maintenance	Help with Installation

Table 5. Top Three Considerations for Survey Respondents on Installing GSI

Top Three City Incentives to Install GSI			
	#1	#2	#3
Incentives	Financial assistance through a rebate	A free consultation with a professional landscape designer	• A decrease in your monthly drainage charge • Physical assistance with maintenance or installation

Table 6. Top Three City Incentives for Survey Respondents to Install GSI

By distinguishing the "considerations" based on those who said they had installed either of these GSI systems, those that said they would be willing to install both, and those that said they would never install either, more specific patterns emerged. In almost all instances, "cost" and "maintenance" continue to be the top two most important "considerations" for respondents, though now "maintenance" is sometimes the primary "consideration" with rain gardens. There is greater distinction in the third tier "considerations" as the following Tables 3, 4, and 5 demonstrate.

Top Three Considerations for Innovators			
	#1	#2	#3
Rain Gardens	Maintenance	Cost	Aesthetics
Cisterns	Cost	Maintenance	Aesthetics

Table 7. Top three considerations for survey respondents who already had installed GSI

Top Three Considerations for Early Adopters			
	#1	#2	#3
Rain Gardens	Cost	Maintenance	Help with Installation
Cisterns	Cost	Maintenance	Help with Installation

Table 8. Top three considerations for survey respondents who would be willing to install GSI

Top Three Considerations for Late Majority/Laggards			
	#1	#2	#3
Rain Gardens	Maintenance	Limited Space	Aesthetics
Cisterns	Cost	Maintenance	Limited Space

Table 9. Top three considerations for survey respondents who would not be willing to install GSI

II. GSI as an Innovation Summary

I have both. Rain garden is just a declivity, I installed it myself. Barrels must be set up by someone good at plumbing connections. The rebates are awesome.
-Anonymous Survey Response on GSI

The city rebates are often too tedious, so a decrease monthly in the drainage charge, or just ability to by pre-discounted equipment would be better.
-Anonymous Survey Response on GSI Incentives

In sum, survey responses demonstrate that the perceived characteristics of these innovations are viewed as having potential benefits. This is evident in the amount of respondents who stated they would be willing to adopt these GSI and it is an encouraging sign for the WPD. However, there are apparent barriers to greater diffusion. Low perceived relative advantage for example, in terms of cost and maintenance, are the primary obstacles. Additionally, the relative advantages that these GSI offer in terms of "environmental benefits", are either not very apparent currently or it is not a attribute that is as significant relative to others. The aesthetics and design of these GSI will be an important perceived characteristic to

consider for the WPD, as demonstrated by the responses of those individuals –the innovators- who have already installed these GSI systems. Additionally, how to reduce the perceived and actual complexity of these innovations -in terms of installation- will be a critical factor, especially in the initial stages of the diffusion process (this was the third most significant "consideration" for those willing to adopt).

Speaking to cost specifically, the fact that residents expressed an unwillingness to spend greater than $500 for these innovations will be an additional challenge for the WPD, as not only do these systems often cost more to purchase and install but also because this survey sample represents a relatively affluent demographic. In other words this is a group of individuals who have a greater financial ability to spend more, relative to the Austin population at large. It may be the case that this is the perceived monetary worth of these innovations or on the other hand, given that most respondents do not spend more than this on their yards in general, $500 may be a general spending threshold for most residents. The fact that a majority of individuals were not aware that the City of Austin offered rebates for these GSI is an apparent opportunity for the WPD to take advantage of. This is especially true given that "financial assistance through a rebate" was the preferred incentive. However, if these rebates are not able to reduce the cost to this $500 threshold, it will be even more important for the WPD to promote the perceived and actual relative advantage and compatibility characteristics of these systems while also reducing their complexity.

GSI and Time (Hypothesis 4-9)

I. Awareness-Knowledge (Hypothesis 4-5)

I believe they are illegal?
-Anonymous Survey Response on Cisterns

I have mature trees on my property and I wouldn't want to negatively impact their root zone. I would need to know the best place considering mature trees.
-Anonymous Survey Response on Rain Gardens

To investigate existing awareness-knowledge of these innovations and whether this will translate into information seeking –and potentially adoption- the survey asked three simple questions: "Are you familiar with what a rain garden is?", "Are you familiar with what a rainwater harvesting cistern or tank is?", and "Would you like to receive more information on rain gardens and cisterns from the City of Austin's Watershed Protection Department?". To explore respondent's environmental values and whether a stronger environmental ethic would lead to an increase in information-seeking, six questions were asked concerning the environment, which can be found in Appendix D, Section D of the Survey.

H4. "Awareness-knowledge" of rain gardens and cisterns will be low relative to total survey responses.

H5. Greater expressed concern for the environment will be a motivating factor and have a positive effect on an expressed request for more information

II. Awareness-Knowledge Discussion

A lot of the cisterns I've researched online are plastic and I can't find much information on the effects of the Texas Sun on them.
-Anonymous Survey Response on Cisterns

I am not really sure on the requirements or how to make one.
-Anonymous Survey Response on Rain Gardens

Overall there was a dramatic difference between awareness-knowledge of rain gardens as compared to cisterns. While nearly all survey takers expressed a familiarity with cisterns, over half were not familiar with rain gardens. Though this may in part reflect the same confusion observed earlier over cisterns versus rain barrels, given the degree of disparity between the two, it is likely that it is much earlier on in the diffusion process of rain barrels as an innovation. While there is this lack of familiarity, it is a promising sign for the WPD that when asked whether they would like to receive more information on rain gardens and cisterns from the City of Austin WPD, a majority of

respondents –or 72%- responded in the affirmative. The following Figure 14 represents this disparity in awareness-knowledge between rain gardens and cisterns.

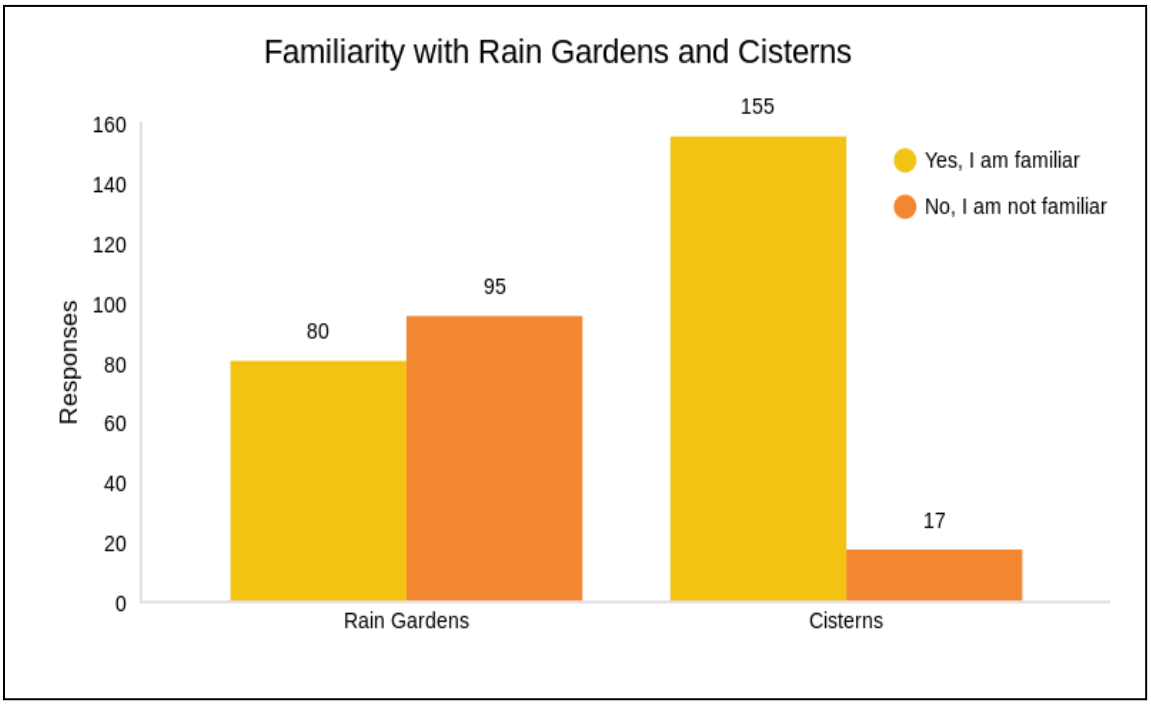


Figure 15. Familiarity with Rain Gardens and Cisterns

In terms of environmental values, survey responses overwhelmingly stated that the environmental quality of both their local creek and Austin's Lady Bird Lake were either "somewhat" or "strongly" important to them. Furthermore, when prompted on whether residential yards can have an effect on the environmental quality of Austin's creeks and lakes, an equivalent majority of responses agreed that they can. Lastly, approximately the same amount of individuals stated that they were "somewhat" or "strongly" concerned about the "possibility of future droughts in Austin". However, despite these avowed concerns, there was a marked decrease in the number of people who either "somewhat" or "strongly" agreed that they would either "like to do more to help improve the environmental quality of Austin's creeks and lakes" or "work with the City of Austin in efforts to improve the environmental quality of Austin's creeks and lakes". This was especially true for whether or not people would be willing to work with the City. The following Figure 15 represents these results.

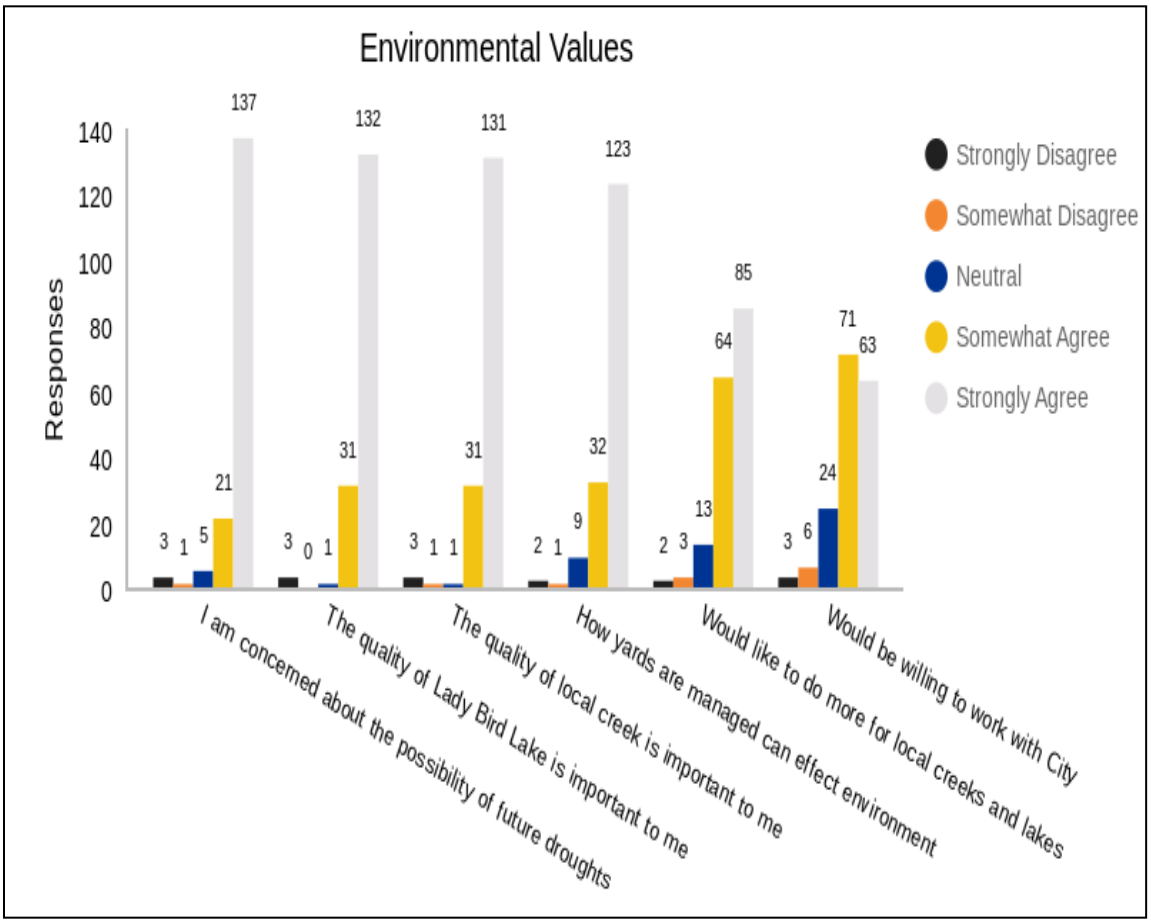


Figure 16. Environmental Values

III. Awareness-Knowledge Summary

We have one and I doubt we have saved money nor helped the environment as we have had drought for 5 years and thus no rain to use. Then when it rains, you don't need the cistern.
-Anonymous Survey Response on Cisterns

If it would lower my PROPERTY TAXES, I would look into it.
-Anonymous Survey Response on GSI

Not only have relatively few of these GSI systems been installed to this date, but when it comes to rain gardens there is a significant lack of awareness-knowledge as well. It is therefore very early on in the diffusion process for both of these innovations. At this point, it is apparent that promoting greater general awareness of rain gardens will be an important first step for the WPD. In terms of cisterns, it will require more informed

communication strategies: because there is this familiarity more individuals will have pre-existing perceptions of this GSI. Though it is early in the diffusion process, the perceived potential benefits of these innovations are meaningful enough that individuals want to know more: when asked whether they would like to receive information from the City of Austin. 119 of 165 responses (or 72%) replied in the affirmative. Even if this may again be due to survey bias, it is another positive sign for the WPD.

However, the amount of individuals who had expressed that they would be willing to install GSI (e.g. 142 individuals said they would consider installing a rain garden) was greater than the number of individuals who requested more information. Why the difference? Presumably if someone had expressed that they would consider installation they would also request more information (especially if they "strongly agree" that the environmental quality of Lady Bird Lake or their local creek is important to them, for example)? Despite the fact that this survey sampled individuals who have strong environmental ethic and awareness overall, the environmental benefits that these innovations provide may not be a compelling enough characteristic to learn more and eventually install them. As discussed earlier, this is because either these benefits that the innovations provide are not yet evident or that they are not a relative advantage that is valued (as much as aesthetics for instance). Another factor to consider is the willingness of residents –or lack thereof- to proactively align their environmental values with action. As evidenced in Figure 15, there are far fewer individuals who either "somewhat agree" or "strongly agree" that they would like to do more for local creeks and lakes and especially if that entails working with the City.

IV. Innovativeness (Hypothesis 6-9)

I'm old and can't do heavy yard work.
-Anonymous Survey Response on Rain Gardens

I am retired and have much less money than I did when I worked. The lack of money controls everything I do or want to do.
-Anonymous Survey Response

To better understand the adopter categories and their nature of innovativeness in relationship to these innovations, a series of questions were included in the survey seeking socio-economic information. These questions can be found in Appendix D,

section E of the survey. The demographic information (i.e. age, income, education, time lived in Austin, time live in current residence), was then analyzed based on three adopter categories: those who have already installed rain gardens or cisterns, those that said they would install both, and those individuals who said they would never install either.

H6. Innovators and early adopters –those that have or said they'd be willing to install these systems- will have higher levels of formal education and income.

H7. Greater levels of formal education and income will be positively related to the amount of individuals who would be willing to adopt rain gardens and cisterns.

H8. Age will not be a factor in an expressed willingness to adopt rain gardens and cisterns.

H9. Age will not be a factor for individuals who have already adopted rain gardens and cisterns.

V. Innovativeness Discussion

I'm the landlord. My renter doesn't seem to be concerned with gardening or watering which is ok with me as long as the yard doesn't get too messy looking.
-Anonymous Survey Response

Our landlord already installed one at our request.
-Anonymous Survey Response

By breaking down the demographic information into adopter categories some clear patterns emerged. Innovators and early adopters were, relative to those that said they would not adopt: more educated, wealthier, and younger. For those that said they had already installed either rain gardens or cisterns, over 93% of respondents had a four-year degree or post graduate degree. For those individuals that said they would, approximately 85% had the equivalent level of education. For those who said they would never (the late majority or laggards), only about 50% had a similar degree of educational attainment. In terms of income, over 60% of

respondents of both innovators and early adopters earned over $80,000 annually, compared to only 42% of those who said they would not adopt. With regards to age, the differences between the categories were not as stark though they were still apparent. Finally, in terms of the amount of time lived in both Austin and at their current residences, there was little difference between the adopter categories. The following Table 5 presents the average and median age of innovators, early adopters, and late majority or laggards. Figure 16 and 17 represent the educational attainment and annual income for these three categories.

Average and Median Age of Adopter Categories			
	Total Individuals	Average Age	Median Age
Have Installed Either GSI	30	49.8	49
Would Install Both GSI	100	44.5	41.5
Would Not Install Both GSI	12	56.3	56.5

Table 10. Average and Median Age of Adopter Categories

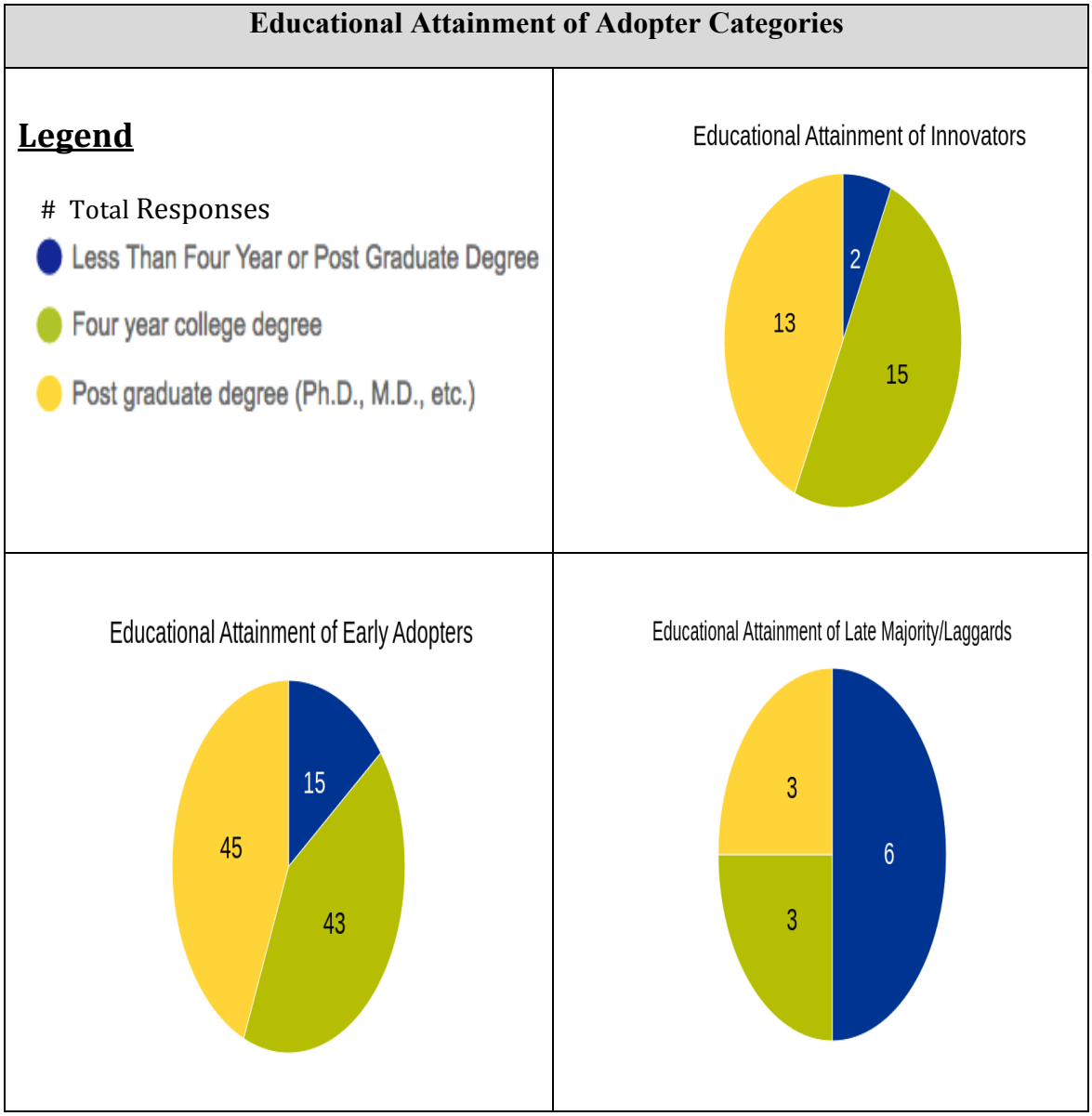


Figure 17. Educational Attainment of Adopter Categories by Total Responses

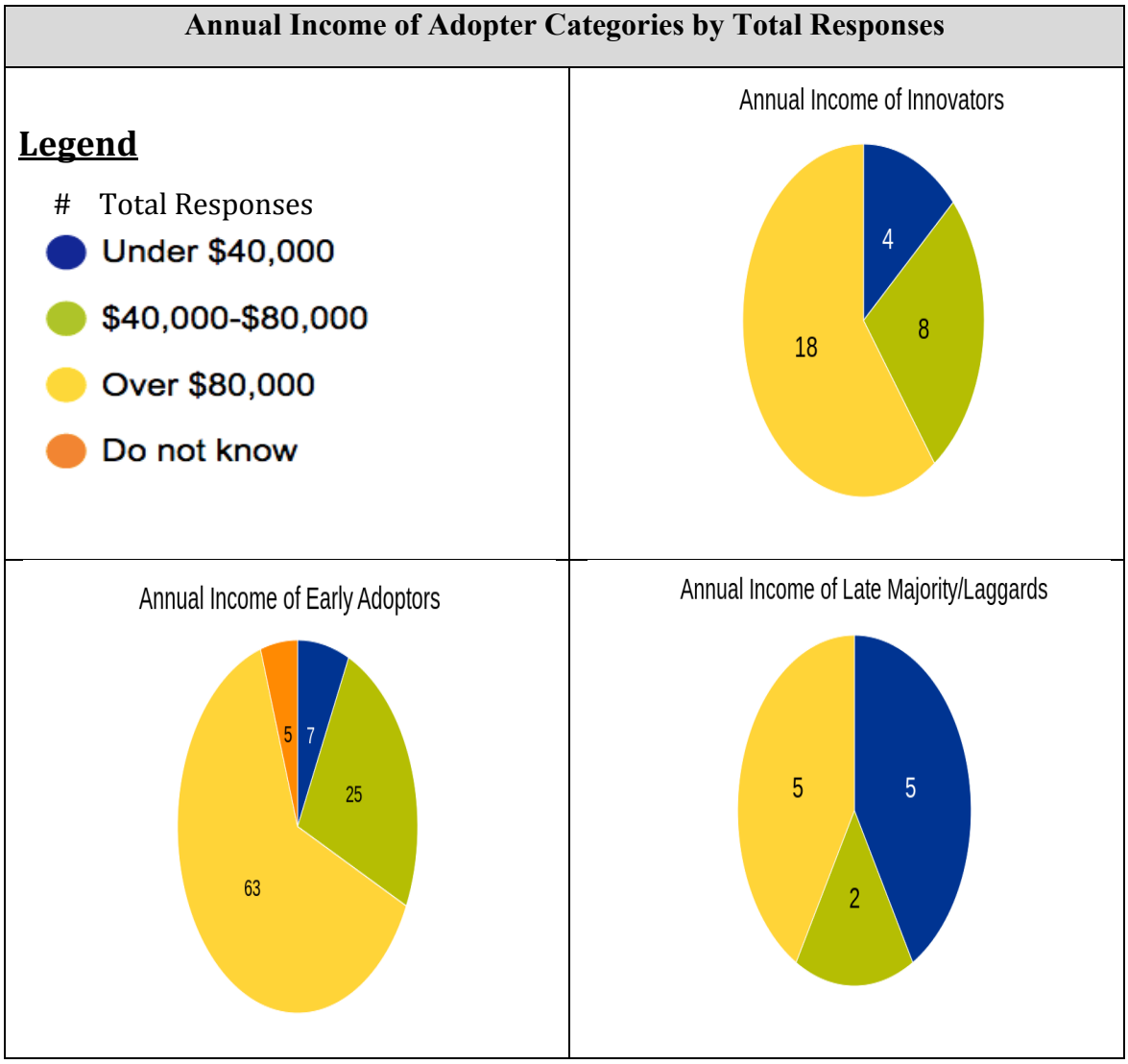


Figure 18. Annual Income of Adopter Categories by Total Responses

VI. **Innovativeness Summary**

I am old and probably will not be here long. If my house is sold someone will demolish the house and build a large, less nice house. If I were younger I might consider a larger water tank if it could be kept clean.
-Anonymous Survey Response on Rain Gardens

Moving due to rising rent: who would maintain?
-Anonymous Survey Response on Cisterns

Despite the fact that this survey sample measures a socio-economic demographic that over-represents a wealthier and more educated segment of the population, clear and predictable patterns still emerged within the three adopter categories. Diffusion of

Innovation research has found that the initial stages of diffusion will begin with certain types of individuals -innovators and early adopters- which can be characteristically more affluent and have higher educational attainment. With innovators this is especially true, because as Everett Rogers notes: "control of substantial financial resources is helpful in absorbing the possible losses from an unprofitable innovation"[188] and in terms of educational attainment, "the ability to understand and apply complex technical knowledge is also needed."[189] Understanding the nature of innovators when it comes to the diffusion of particular innovations is particularly important in that they serve to launch the new idea by "importing the innovation from outside of the system's boundaries."[190] Early adopters, while not as "venturesome"[191] as innovators are just as critical to the diffusion process. This adopter category, more than any other, influences the spread of a new idea and is often utilized by agencies or individuals to speed the diffusion process.[192]

Survey results in this case align with expectations. Based on this survey sample, the innovators –the six individuals who had installed rain gardens and twenty-six who had cisterns- were more affluent and had higher levels of educational attainment than those individuals who stated they would not consider adopting these GSI. This was also true for the potential early adopters. While age is not always an explanatory factor in diffusion, based on these results it is likely that diffusion of these innovations will also be more rapid with a younger demographic. Conversely, the WPD will likely find diffusion of these innovations to proceed more slowly for those demographics that have less disposable income, are older, and have lower degrees of educational attainment.

GSI and the Social System (Hypothesis 10)

I love my yard.
-Anonymous Survey Response

It has been fine for the 40 years I have lived here; I don't need newcomers to try to regulate MY yard.
-Anonymous Survey Response

[188] Rogers, 282
[189] Rogers, 282
[190] Rogers, 283
[191] Rogers, 282
[192] Rogers, 283

To investigate social norms when it comes to yard use and what may be opportunities or barriers to the diffusion of GSI, five questions -found in Appendix D, Section B and C of the survey- sought information on how yards were being utilized currently and what were the barriers people faced to having their ideal yard. Respondents were asked to rate on a scale of one to five how important certain characteristics and barriers of their ideal yards were (e.g. 1 = Not important to 5 = Very important). To measure relative value each category was then given a weighted average score (from 1 to 5) based on total responses for each ranking. To further examine how these norms might differ between adopter categories, these questions were filtered by: those that said they had installed either rain gardens or cisterns, those who said they would be willing to install both rain gardens or cisterns, and those that said they wouldn't install either.

H10. Survey respondents will prioritize cultural ecosystem services (e.g. aesthetics) as opposed to provisioning, regulating, or supporting ecosystem services (e.g. biodiversity)

I. GSI and the Social System Discussion

Anywhere in this survey about the use of herbicides and pesticides that are making urban living toxic?
-Anonymous Survey Response

I want a nice, neat yard that is easy to install, easy and inexpensive to maintain and good for the environment.
-Anonymous Survey Response

Overall survey results showed that overwhelmingly people do value their yards: only about 8% of all respondents listed that their yards did not interest them. Additionally results revealed that when it comes to the characteristics of these yards, the most important quality by far is to "have trees for shade and cooling or to improve air quality". The second and third most important qualities of people's yards were: "a yard that requires little watering" and "a yard that is not expensive to maintain". Those qualities of people's yards that received the lowest score were: "a xeriscape yard, with rocks and gravel" followed by "a grassy, green lawn" and "a yard that aesthetically matches or blends in with the look of the neighborhood". The biggest barriers for

individuals to having their "ideal yard" were: "money", followed by "time", and then "knowledge". The following Tables 6 and 7 report these findings.

Most Important Yard Characteristics	
"It is important for me to (have)…" (1=Not Important, 2=Not very important, 3=Neutral/no opinion, 4= Somewhat important, 5= Very important)	Average Score
trees for shade and cooling or to improve air quality	4.38
a yard that requires little watering	4.18
a yard that is not expensive to maintain	4.14
a space for kids, visitors, or pets, to use and be active	4.05
a yard that is easy to maintain: requiring little mowing or weeding	4.02
improve the health of our creeks or lakes	3.92
an area that provides wildlife habitat for animals like birds or pollinators	3.92
attractive flowers and plants	3.74
a way to reduce flooding or erosion in the yard	3.63
privacy from neighboring yards or the street	3.63
a way to contribute to the value of the property	3.61
space to have plants, animals, or materials for food, medicine, or crafts	3.60
a way to connect to where you live: learning about what grows and lives in central Texas	3.48
a yard that has a variety of plants or mimics nature	3.47
an area to care for and be creative	3.44
harvest or collect rainwater	3.44
have space for composting at home	3.15
a yard that aesthetically matches or blends in with the look of the neighborhood	2.83
a grassy, green lawn	2.81
a Xeriscape yard, with rocks and gravel	2.73

Table 11. Yard Management Preferences

Top Barriers to Having an Ideal Yard	
"The following is a list of some reasons why people don't have the yards they would like…" (1=Strongly disagree, 2=Disagree, 3=Neutral/no opinion, 4= Agree, 5= Strongly Agree)	Average Score
Money: don't have or want to spend the money on it now	3.56
Time: don't have the time for it currently	3.37
Knowledge: unsure of how to get it to look the way I want	3.32
Other. please describe	2.99
No barriers: my yard is how I want it	2.69
Physical: unable to do the work	2.49
Space: I do not have the space in my yard for what I want	2.10
Interest: I am not interested in this kind of thing	1.85
Moving: I do not plan to stay at my current residence for very long	1.81
Prohibited: the rules of a homeowner association, lease agreement or city restrictions	1.66
Appearances: it wouldn't fit in with the neighborhood look	1.59
Ownership: I rent	1.52

Table 12. Reasons Why People Don't Have the Yards They Would Like

In terms of yard use and the different adopter categories, distinctions were again evident. For innovators, the most important qualities when it came to their yards strongly favored provisioning, regulating, and supporting ecosystem services. Additionally, when it came to their "ideal yard", nearly 50% of innovators either agreed or strongly agreed that there were "no barriers". On the other hand, the values of the early adopter category reflected very utilitarian considerations, with "money", "knowledge", and then "time" as being the biggest obstacles to having their ideal yard. Similarly, the late adopter and laggard category prioritized yards that require little effort, selecting "a yard that is not expensive to maintain" and "a yard that is easy to maintain: requiring little mowing or weeding" as their top two preferred yard characteristics. The following Tables 8 and 9 show the top three most valued yard characteristics and barriers for each of the three adopter categories.

Most Important Yard Characteristics of Adopter Categories		
	Top Three Preferred Yard Characteristics	Average Score
Innovators	(#1) Trees for shade and cooling or to improve air quality	4.63
	(#2) Improve the health of our creeks or lakes	4.37
	(#3) An area that provides wildlife habitat for animals like birds or pollinators	4.27
Early Adopters	(#1) Trees for shade and cooling or to improve air quality	4.38
	(#2) A yard that requires little watering	4.21
	(#3) A yard that is not expensive to maintain	4.11
Late Majority/Laggards	(#1) A yard that is not expensive to maintain	4.75
	(#2) A yard that is easy to maintain: requiring little mowing or weeding	4.75
	(#3) Trees for shade and cooling or to improve air quality	4.42

Table 13. Yard Management Preferences for Adopter Categories

Barriers to an Ideal Yard of Adopter Categories		
	Top Three Barriers	Average Score
Innovators	(#1) No barriers: my yard is how I want it	3.14
	(#2) Knowledge: unsure of how to get it to look the way I want	2.97
	(#3) Other. please describe	2.85
Early Adopters	(#1) Money: don't have or want to spend the money on it now	3.78
	(#2) Knowledge: unsure of how to get it to look the way I want	3.61
	(#2) Time: don't have the time for it currently	3.54
Late Majority/Laggards	(#1) Money: don't have or want to spend the money on it now	3.75
	(#2) Time: don't have the time for it currently	3.67
	(#3) Other. please describe	3.44

Table 14. Barriers to Having an Ideal Yards for Adopter Categories

I. GSI and the Social System Summary

Matching compatibility with children/dogs/chickens/garden with limited space. Mitigating fire ants and mosquitoes while having play areas etc.
-Anonymous Survey Response on Barriers to Ideal Yard

Mosquitoes!
-Anonymous Survey Response on GSI

This survey has yielded interesting results in terms of preferred yard characteristics and the social or cultural norms that are involved in their management. Reflecting similar sentiments expressed about the GSI innovations, respondents prioritize yards that are not a burden: in terms of time, money, and effort. This is not due to apathy either as evidenced by the fact that yards are in fact something important to residents. Rather, for the majority of individuals the ideal yard is simple and provides the resident with tangible utility: whether that be in the provision of shade by trees or having space

available to be social and active. Returning to the idea of aesthetics and the design of these GSI systems: if it is the case that they add complexity to yard management –or even if this is just how they are perceived- their diffusion will likely be hindered.

Notably, the number one consideration in terms of yard characteristics and management was a regulating and supporting ecosystem service: "to have trees for shade, cooling, or to improve air quality". Moreover this was also a value that was highly regarded across all adopter categories. Considering the temperatures of an Austin summer, the benefits of this ecosystem service are evidently more apparent and appreciated. Whether these GSI systems can incorporate or support this yard characteristic is something important to consider for the WPD.

Apart from the ecosystem services trees contribute, provisioning, regulating, or supporting services were generally not among the most important characteristics of people's yards. It is clear therefore, that though the majority of these individuals have strong environmental values, yards are not currently a context in which they are translated into action or behavior. As noted earlier, the greater compatibility that an innovation has with the norms of a social system the more likely its diffusion. If the WPD can begin to align cultural norms and perspectives on yard management with an individual's avowed environmental values, the more successful they will be in the adoption of these innovations.

This is clearly demonstrated by those individuals who have already adopted GSI. In their case, these innovators consider and prioritize a diversity of ecosystem services in their yard management practices. Though they may rate "aesthetics" over the "environmental benefits" of rain gardens and cisterns specifically, the innovations do align with their yard management norms and environmental values. However, as discussed previously, innovators are also a group of individuals who have greater resources available to realize their ideal yard and adopt these systems. Shifting cultural norms and perspectives on yard management will be important, but as the responses of early adopters demonstrate: time, money, and knowledge are practical barriers that will be equally as significant.

Chapter 9: Survey Summary

Aside from the funds needed, it seems an overwhelming task to tackle.
-Anonymous Survey Response on Barriers to Ideal Yard

Gardening is a slow hobby - my garden isn't exactly how I want it because I know it is going to take years and lots of hard work and care to get there.
-Anonymous Survey Response on Barriers to Ideal Yard

Social change is, as Everett Rogers notes, "one of the most fundamental of human processes".[193] The diffusion of innovations is a type of social change, "a process by which alteration occurs in the structure and function of a social system."[194] There is no certainty however, that an innovation will be adopted. Many require a period of years from their initial introduction or availability to when they become more widely diffused.[195] Even those innovations that have obvious or immediate benefits for individuals are not necessarily successful.[196] It is clear therefore that there is much more involved in diffusion and adoption than just the characteristics of innovations.[197] For this reason many organizations and individuals have strived and worked to understand how this process works and how the rate of diffusion can be sped up. In this case, the WPD and the City of Austin seek to affect a form of social change through the adoption of GSI innovations. This survey and report have investigated how these GSI innovations are currently perceived and what are some barriers to and opportunities for promoting their adoption.

The process of diffusion for both rain gardens and cisterns is in its nascent stages. Not only have relatively few been adopted to date but there exists uncertainty as to what rain gardens are and what may actually constitute a cistern as opposed to a rain barrel. In the early stages of diffusion, reducing the uncertainty surrounding these innovations through outreach and education is needed. Additionally, communication strategies for each GSI will require tailoring and adjustment over time. In the case of cisterns specifically, these strategies will likely need to take into account prior experiences with

[193] Rogers, xviii
[194] Rogers, 6
[195] Rogers, 1
[196] Rogers, 7
[197] Rogers, 8

and impressions of them. As one survey respondent said: "We had one before, but it became a mosquito breeding ground. I would have to know that the design was better than the one we had before to prevent that." In both cases, once uncertainty of these innovations is reduced, it will be important to provide what in diffusion literature is called: "how-to knowledge". As demonstrated by the responses of the potential early adopters, "help with installation" is already a top consideration. While familiarity of these innovations increases over time there will be a greater need for this type of information and assistance.

In terms of the innovations more specifically, it will be important for the WPD to keep in mind two things while moving forward. One, what are the perceived relative advantages of these innovations that can be conveyed to the public and two, can the designs of these GSI be more compatible with existing social and cultural norms. Through the survey, it was discovered that in the case of innovators –those individuals who will be the first to adopt- the aesthetics of both rain gardens and cisterns are important. Furthermore, it was revealed that these individuals also manage yards that could be deemed environmentally conscientious. When considering the design or aesthetics of these systems then, a useful question to ask would be: how can these innovations be yard *amenities* in addition to stormwater infrastructure? For instance, in what ways can they also support "an area that provides wildlife habitat for animals like birds or pollinators"? Or, for example, could cisterns double as a canvas for local artists? The non-profit Word Above the Street, based in New York City, has done just this: with cisterns across the city receiving artistic makeovers in order to foster environmental awareness and alter attitudes and habits. The book "Artful Rainwater Design" will be another useful resource for these purposes. Written by Landscape Architects Stuart Echols and Eliza Pennypacker, they discuss not only why GSI should but also how these systems can manage stormwater runoff while creating inviting, attractive, and desirable landscapes.[198]

Unlike innovators, for early adopters the ideal yard needs to be simple. In fact, the majority of individuals in the Waller Creek Watershed likely face the same challenges to yard management that was expressed in the survey: a lack of time and money. In this

[198] Echols, 2

case, GSI will have greater perceived relative advantage if these systems can make yard management easier. Additionally, ensuring that the design of rain gardens and cisterns themselves does not entail more work for residents is essential. Perhaps installing these systems could even mean individuals are able to spend less time on yard maintenance, if for example a lawn no longer needs to be mowed because it has been replaced by a rain garden. Worth noting again, is the appeal across all adopter categories of having "trees for shade and cooling or to improve air quality". Determining whether GSI can incorporate trees into their design or communicating how these systems can benefit and support trees (or their ecosystem service function: cooling), will aid in diffusion.

It is evident that for both of these innovations the cost of installation and upkeep in addition to maintenance requirements after installation, are significant obstacles in their diffusion. Reducing these barriers in any material way will of course aid in their adoption. The fact that relatively few individuals were aware that rebates are available for example is a clear opportunity for the WPD. Another barrier in their diffusion will likely be an unwillingness of individuals to engage with the WPD or the City of Austin in its efforts. Two initial solutions to this that have been provided by the survey are: one, a list of individuals who did request more information on GSI (provided to the WPD separately from this report) and two, a list of organizations and groups that residents are currently active with (found in Appendix H).

The lists of individuals are a resource to engage with people who may be more inclined to work with the WPD and also consider adoption. Furthermore, as noted earlier, the process of diffusion is one that depends largely on peer-to-peer communication. It is important therefore that these networks of individuals begin to be activated. Not only should this initial engagement include the communication and design strategies just discussed, but it is also a chance to address the remaining two categories of perceived attributes involved in diffusion: trialability and observability. Again, the greater the extent to which an individual can reduce their uncertainty of an innovation by either using it or observing its benefits, the more likely they are to adopt. Perhaps, for example, some of these individuals would be willing to visit GSI demonstration projects to learn more about their purpose and advantages. The list or organizations could also be useful in this regard. As in the case of Prince George County, Maryland, local non-

profits and faith based groups can become involved with stormwater management initiatives to not only provide another avenue of communication but also as willing partners engaged in the installation of GSI.

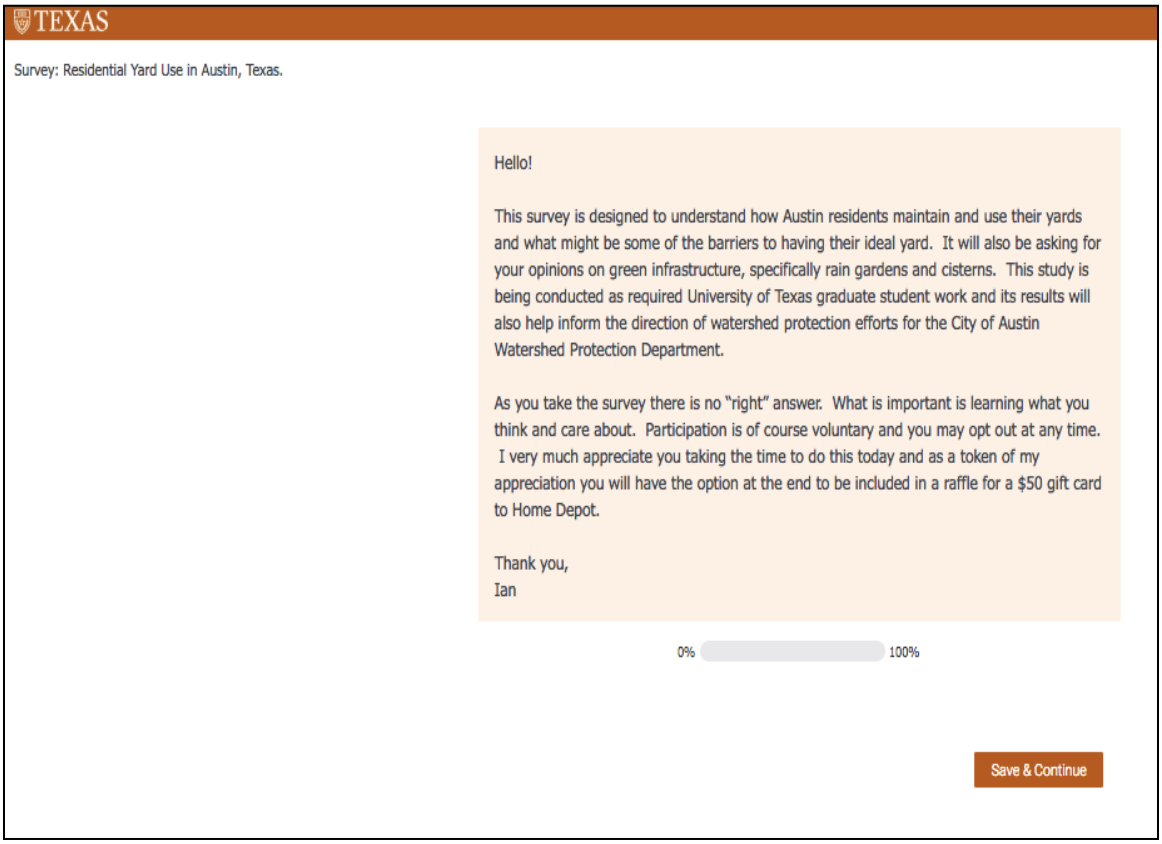
Chapter 10: Conclusion

> Individual ethics is the basis of land conservation. It is hard to make a man do a thing which does not spring naturally from his own personal sense of right and wrong. A land ethic reflects the existence of an ecological conscience. Conservation can accomplish its objectives only when it springs from an impelling conviction on the part of private landowners.[199]
> -Aldo Leopold

The environmental geographer Ruth DeFries once said that in many ways city life "severs our links with the very nature that makes life possible".[200] As this report has explored, this is a link that exists for many Austin residents but is one that may be tenuous. Though an individual may "Strongly Agree" that the "environmental quality of Austin's Lady Bird Lake is important", this sentiment will not necessarily translate into corresponding action or behavior. The reasons for this disconnect are myriad but as agencies like Austin's Watershed Protection Department begin to advocate for decentralized green stormwater infrastructure, it is imperative that they understand not only the science behind these systems but also the perceptions, values, and realities of those residents who they are seeking to work with. The next stage in the evolution of cities and their infrastructure –if it is to take place- will not only be physical but also inevitably both cultural and personal. Whether or not this link between urban citizens, water, and nature can be re-enforced and strengthened may have implications not only for Austin and this Pilot Project but also for the success of efforts towards sustainability in cities everywhere.

[199] Nelle, Steve. "Lessons From Leopold: What is Land Stewardship?". *Hill Country Alliance.* Jan 2017. Web. Jan 2017., 1
[200] DeFries, Ruth. "The World's Urban Future: It's Not All Bad for Nature". *The Huffington Post*. N.d. Web. Sep 2017., 1

Appendix A: Survey Homepage



Appendix B: Online Consent Form

Consent to Participate in Internet Research

Consent to Participate in Internet Research

Identification of Investigator and Purpose of Study

You are invited to participate in a research study, entitled "Residential Yard Care in Austin, Texas." The study is being conducted by Ian Johnston and the School of Architecture of The University of Texas at Austin.

The purpose of this study is to collect information about yard management practices used by residents in the Austin area. This study is being conducted as part of graduate student thesis work and its results will help inform the direction of watershed protection efforts for the city of Austin Watershed Protection Department.

If you agree to participate:

· You must be at least 18 years old.

· The survey will take approximately 10 to 15 minutes of your time.

· You will complete a survey about residential yard care and green infrastructure in Austin

· Upon the completion of the survey you will have the option to enter a drawing for a $50 gift card to Home Depot. The drawing will occur on May 31, 2017, and if you are chosen you will be contacted through information that you voluntarily provide.

Risks/Benefits/Confidentiality of Data

There are no known risks associated with taking this survey. All identifying information voluntarily provided by the participant will be kept separately from survey response information. Therefore, your answers will be anonymous. The safety of this information will be ensured through a password protected USB and computer. All data received will be kept for no longer than

Consent to Participate in Internet Research

three months and will be digitally erased upon the studies completion.

Contacts

If you have any questions about the study contact the researcher Ian Johnston at (512) 553-1979 or send an email to iantjohnston@utexas.edu This study has been reviewed by The University of Texas at Austin Institutional Review Board and the study number is 2017-01-0074

Questions about your rights as a research participant.

If you have questions about your rights or are dissatisfied at any time with any part of this study, you can contact, anonymously if you wish, the Institutional Review Board by phone at (512) 471-8871 or email at orsc@uts.cc.utexas.edu.

If you agree to participate, click "Save and Continue" at the bottom of this page.

Thank you!

Appendix C: In-person Consent Form

Consent for Participation in Research

Title

A Survey of Yard Care in Austin, Texas

Introduction

This form is to provide you information that may affect your decision as to whether or not to participate in this research study. The person performing the research will answer any of your questions. Read the information below and ask any questions you might have before deciding whether or not to take part. If you decide to be involved in this study, this form will be used to record your consent.

Purpose of the Study

You have been asked to participate in a research study about residential yard care in Austin, Texas. The purpose of this study is to collect information about yard management practices used by residents in the Austin area. This study is being conducted as part of graduate student thesis work and its results will help inform the direction of watershed protection efforts for the city of Austin Watershed Protection Department.

What will you be asked to do?

If you agree to participate in this study, you will be asked to take one survey that will take 10 to 15 minutes to complete. The study includes approximately 1,257 participants.

What are the risks involved in this study?

There are no foreseeable risks to participate in this study.

What are the possible benefits of this study?

You will receive no direct benefit from participating in this study; however, with the information you provide the city of Austin will better be able to protect our local watersheds.

Do you have to participate?

No, your participation is voluntary. You may decide not to participate at all or, if you start the study, you may withdraw at any time. Withdrawal or refusing to participate will not affect your relationship with The University of Texas at Austin in anyway.

If you would like to participate, please return this signed form with the survey in person to Ian Johnston. You will receive a copy of this form.

Will there be any compensation?

Upon the completion of the survey you will have the option to enter a drawing for a $50 gift card to Home Depot. The drawing will occur on August 1st, 2017, and if you are chosen you will be contacted through information that you voluntarily provide.

How will your privacy and confidentiality be protected if you participate in this research study?

All identifying information provided by the participant will be submitted separately from survey response information. Therefore, the survey questions will be anonymous. All data from the survey itself will also be kept confidential. The safety of this information will be ensured through a password protected USB and computer. Written surveys will be kept in a locked space at the University of Texas while the study is being conducted. All data received will be kept for no longer than three months and will be digitally erased and/or manually shredded upon the studies completion. Any personally identifying information will only be

Consent for Participation in Research

asked for if participants wish to be included in the drawing and will be kept separate from survey responses to ensure anonymity.

If it becomes necessary for the Institutional Review Board to review the study records, information that can be linked to you will be protected to the extent permitted by law. Your research records will not be released without your consent unless required by law or a court order. The data resulting from your participation may be made available to other researchers in the future for research purposes not detailed within this consent form. In these cases, the data will contain no identifying information that could associate it with you, or with your participation in any study.

Whom to contact with questions about the study?

Prior, during, or after your participation you can contact the research: Ian Johnston, at (512) 553-1979 or by email to iantjohnston@utexas.edu if you have any questions or concerns. This study has been reviewed and approved by the University Institutional Review Board and the study number is 2017-01-0074.

Whom to contact with questions concerning your rights as a research participant?

For questions about your rights or any dissatisfaction with any part of this study, you can contact, anonymously if you wish, the Institutional Review Board by phone at (512) 471-8871 or email at orsc@uts.cc.utexas.edu.

Participation

If you agree to participate please return signed forms to Ian Johnston in person.

Signature

You have been informed about this study's purpose, procedures, possible benefits and risks, and you have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time. You voluntarily agree to participate in this study. By signing this form, you are not waiving any of your legal rights.

I have read the above information, and have received answers to any questions. I affirm that I am 18 years of age or older. I consent to take part in this research study.

_____
Printed Name

_____ _____
Signature Date

As a representative of this study, I have explained the purpose, procedures, benefits, and the risks involved in this research study.

_____
Print Name of Person obtaining consent

_____ _____
Signature of Person obtaining consent Date

Appendix D: Survey

Survey: Residential Yard Use in Austin, Texas

Ian Johnston. School of Architecture. University of Texas

A. Rain Gardens and Cisterns

Please check or rank the answers that best fit

(1) Are you familiar with what a rain garden is?

_____*Yes*
_____*No*

If not, a rain garden is a low area that absorbs and filters rainwater runoff that comes from roofs, sidewalks, and driveways. Rain runs off the hard surfaces, collects in the shallow depression, and slowly soaks into the soil. They can help reduce erosion and improve overall health of local creeks. The cost and size of rain gardens can vary depending on design, plants, and materials used.

(2) Would you consider installing a rain garden at your current residence?

_____*Yes*
_____*No*
_____*I have one*

(3) Of the following, what would be the three most important things to consider when deciding on whether or not to install a rain garden at your current residence?

Please rank three of the following in order of importance
(1=most important, 2=second most important, and 3= third most important)

_____Limited space
_____Aesthetics
_____Maintenance
_____Environmental benefits
_____Cost
_____Reducing monthly water utility bill
_____Help with installation
_____Not enough time
_____Permission from a landlord
_____Other: *Please List:*_____
_____

(4) How much would you be willing to pay today to install a rain garden?

_____$0-$100
_____$101- $500
_____ $501 - $1000
_____$1001- $5000
_____Over $5000
_____I would never install one

(5) Are you familiar with what a rainwater harvesting cistern or tank is?

_____*Yes*
_____*No*

If not, a rainwater harvesting cistern or tank collects large amounts of rainwater from your roof and holds it. This water can either be allowed to slowly infiltrate into the ground or be available for you to use at a later date. They can also help reduce erosion and improve overall health of local creeks. The size of these cisterns or tanks can range from 500 gallons to around 3000 gallons and cost will vary depending on size and design.

1

Survey: Residential Yard Use in Austin, Texas
Ian Johnston. School of Architecture. University of Texas

(6) Would you consider installing a rainwater harvesting cistern or tank at your current residence?

_____*Yes*
_____*No*
_____*I have one*

(7) Of the following, what would be the three most important things to consider when deciding on whether or not to install a cistern?

Please rank three of the following in order of importance
(1=most important, 2=second most important, and 3= third most important)

_____Limited space
_____Aesthetics
_____Maintenance
_____Environmental benefits
_____Cost
_____Reducing monthly water utility bill
_____Help with installation
_____Not enough time
_____Permission from a landlord
_____Other. *Please List:*_____

_____

_____

(8) How much would you be willing to pay today to install a cistern or tank?

_____$0-$100
_____$101- $500
_____ $501 - $1000
_____$1001- $5000
_____Over $5000
_____I would never install one

(9) Which of the following incentives would be most likely to motivate you to install a rain garden or cistern at your current residence?

Please rank three of the following in order of importance
(1=most likely, 2=second most likely, and 3= third most likely)

_____Financial assistance through a rebate
_____A free consultation with a professional landscape designer
_____ A reduction in impervious cover or Floor Area Ratio limits
_____ A decrease in your monthly drainage charge
_____An award or public recognition
_____Physical assistance with maintenance or installation
_____Other *Please List:*_____

_____

_____

(10) Were you aware that the City of Austin offers rebates for rain gardens and cisterns?

_____Yes
_____No

Survey: Residential Yard Use in Austin, Texas

Ian Johnston. School of Architecture. University of Texas

B. Your Yard Management Preferences

Please check the answers that best fit

(1) About how much do you spend on yard maintenance and yard care in a year?

_____$0 - $100
_____$101- $500
_____ $501 - $1000
_____$1001 - $5000
_____Over $5000

Please rate how important the following are when it comes to the use of your yard

(1= Not important, 2= Not very important, 3= Neutral/no opinion, 4=Somewhat important, 5= Very important)

(2) It is important for me to have…	**1**	**2**	**3**	**4**	**5**
a space for kids, visitors, or pets, to use and be active					
an area to care for and be creative					
privacy from neighboring yards or the street					
a way to connect to where you live: learning about what grows and lives in central Texas					
space to have plants, animals, or materials for food, medicine, or crafts					

Please rate how important the following are when it comes to yard maintenance and yard care

(1= Not important, 2= Not very important, 3= Neutral/no opinion, 4=Somewhat important, 5= Very important)

(3) It is important for me to have…	**1**	**2**	**3**	**4**	**5**
a yard that requires little watering					
a grassy, green lawn					
a yard that is not expensive to maintain					
a way to reduce flooding or erosion in the yard					
a yard that is easy to maintain: requiring little mowing or weeding					

Please rate how important the following are when it comes to the look of your yard

(1= Not important, 2= Not very important, 3= Neutral/no opinion, 4=Somewhat important, 5= Very important)

(4) It is important for me to have…	**1**	**2**	**3**	**4**	**5**
a yard that has a variety of plants or mimics nature					
attractive flowers and plants					
a yard that aesthetically matches or blends in with the look of the neighborhood					
a Xeriscape yard, with rocks and gravel					
a way to contribute to the value of the property					

Please rate how important the following are when it comes to your yard and nature

(1= Not important, 2= Not very important, 3= Neutral/no opinion, 4=Somewhat important, 5= Very important)

(5) It is important for me to…	**1**	**2**	**3**	**4**	**5**
have space for composting at home					
improve the health of our creeks or lakes					
have trees for shade and cooling or to improve air quality					
harvest or collect rainwater					
have an area that provides wildlife habitat for animals like birds or pollinators					

Survey: Residential Yard Use in Austin, Texas

Ian Johnston. School of Architecture. University of Texas

C. Changes to your Yard

The following is a list of some reasons why people don't have the yards they would like. Please check to what degree, if any, the following is true for you.

(1=strongly disagree, 2= Disagree, 3= Neutral/no opinion, 4=Agree, 5= Strongly Agree)

	1	2	3	4	5
No barriers: my yard is how I want it					
Space: I do not have the space in my yard for what I want					
Time: don't have the time for it currently					
Money: don't have or want to spend the money on it now					
Knowledge: unsure of how to get it to look the way I want					
Physical: unable to do the work					
Interest: I am not interested in this kind of thing					
Prohibited: the rules of a homeowner association, lease agreement, or city restrictions					
Appearances: it wouldn't fit in with the neighborhood look					
Moving: I do not plan to stay at my current residence for very long					
Ownership: I rent					
Other: *Please Describe:*					

D. Your opinion on environmental issues in your community

Please circle the answer that best fits

(1) The environmental quality of my local creek is important to me

Strongly Disagree Somewhat Disagree Neutral Somewhat Agree Strongly Agree

(2) The environmental quality of Austin's Lady Bird Lake is important to me

Strongly Disagree Somewhat Disagree Neutral Somewhat Agree Strongly Agree

(3) I am concerned about the possibility of future droughts in Austin

Strongly Disagree Somewhat Disagree Neutral Somewhat Agree Strongly Agree

(4) How residential yards are managed can have an effect on the environmental quality of creeks and lakes

Strongly Disagree Somewhat Disagree Neutral Somewhat Agree Strongly Agree

(5) I would like to do more to help improve the environmental quality of Austin's creeks and lakes

Strongly Disagree Somewhat Disagree Neutral Somewhat Agree Strongly Agree

(6) I would be willing to work with the City of Austin in efforts to improve the environmental quality of Austin's creeks and lakes

Strongly Disagree Somewhat Disagree Neutral Somewhat Agree Strongly Agree

Survey: Residential Yard Use in Austin, Texas
Ian Johnston. School of Architecture. University of Texas

E. Your General Information

Do you rent or own your current residence? _____Rent _____Own	**What is your age?** _____Years
How long have you lived in Austin? _____Less than 1 year _____1 to 5 years _____5 to 10 years _____10 years or more	**How long have you lived at your current residence?** _____Less than 1 year _____1 to 5 years _____5 to 10 years _____10 years or more

What are the primary language(s) spoken at home?
_____English
_____Spanish
_____Cantonese
_____Mandarin
_____Vietnamese
_____Tagalog
_____ Other: *Please List:*_____

What is the highest level of education that you have completed?
_____Junior high school or less (1rst to 8th grade)
_____Some high school
_____Earned a high school diploma or GED
_____Some college or technical school (no degree)
_____Two-year college degree
_____Four-year college degree
_____Post graduate degree (Ph.D., MD, etc.)

Which annual income category best fits your household (before taxes)?
_____Under $20,000
_____$20,001 - $40,000
_____$40,001 - $60,000
_____$60,001 - $80,000
_____$80,001 - $100,000
_____$100,001 - $150,000
_____$150,001 or more
_____Do not know

Do you consider yourself an active member of any community, religious, trade, environmental, or social organizations?
_____No
_____Yes: Please list:_____
_____
_____
_____

5

Appendix E: IRB Approval Letter

OFFICE OF RESEARCH SUPPORT

THE UNIVERSITY OF TEXAS AT AUSTIN

P.O. Box 7426, Austin, Texas 78713 · Mail Code A3200
(512) 471-8871 · FAX (512) 471-8873

FWA # 00002030

Date: 04/27/17

PI: Robert F Young

Dept: Architecture

Title: The Value of Ecosystem Services in Residential Landscapes: A Study of Waller Creek 3 Sub- Watershed, Austin, TX

Re: IRB Exempt Determination for Protocol Number 2017-01-0074

Dear Robert F Young:

Recognition of Exempt status based on 45 CFR 46.101(b)(2).

Qualifying Period: 04/27/2017 to 04/26/2020. *Expires 12 a.m. [midnight] of this date.*
A continuing review report must be submitted in three years if the research is ongoing.

Responsibilities of the Principal Investigator:

Research that is determined to be Exempt from Institutional Review Board (IRB) review is not exempt from ensuring protection of human subjects. The Principal Investigator (PI) is responsible for the following throughout the conduct of the research study:

1. Assuring that all investigators and co-principal investigators are trained in the ethical principles, relevant federal regulations, and institutional policies governing human subject research.
2. Disclosing to the subjects that the activities involve research and that participation is voluntary during the informed consent process.
3. Providing subjects with pertinent information (e.g., risks and benefits, contact information for investigators and ORS) and ensuring that human subjects will voluntarily consent to participate in the research when appropriate (e.g., surveys, interviews).
4. Assuring the subjects will be selected equitably, so that the risks and benefits of the research are justly distributed.
5. Assuring that the IRB will be immediately informed of any information or unanticipated problems that may increase the risk to the subjects and cause the category of review to be reclassified to expedited or full board review.

6. Assuring that the IRB will be immediately informed of any complaints from subjects regarding their risks and benefits.

7. Assuring that the privacy of the subjects and the confidentiality of the research data will be maintained appropriately to ensure minimal risks to subjects.

8. Reporting, by submission of an amendment request, any changes in the research study that alter the level of risk to subjects.

These criteria are specified in the PI Assurance Statement that was signed before determination of exempt status was granted. The PI's signature acknowledges that they understand and accept these conditions. Refer to the Office of Research Support (ORS) website www.utexas.edu/irb for specific information on training, voluntary informed consent, privacy, and how to notify the IRB of unanticipated problems.

1. Closure: Upon completion of the research study, a Closure Report must be submitted to the ORS.

2. Unanticipated Problems: Any unanticipated problems or complaints must be reported to the IRB/ORS immediately. Further information concerning unanticipated problems can be found in the IRB Policies and Procedure Manual.

3. Continuing Review: A Continuing Review Report must be submitted if the study will continue beyond the three year qualifying period.

4. Amendments: Modifications that affect the exempt category or the criteria for exempt determination must be submitted as an amendment. Investigators are strongly encouraged to contact the IRB Program Coordinator(s) to describe any changes prior to submitting an amendment. The IRB Program Coordinator(s) can help investigators determine if a formal amendment is necessary or if the modification does not require a formal amendment process.

If you have any questions contact the ORS by phone at (512) 471-8871 or via e-mail at orsc@uts.cc.utexas.edu.

Sincerely,

James P. Wilson

James Wilson, Ph.D.
Institutional Review Board Chair

Appendix F: Next Door and Facebook Messages

Is your yard beautiful, relaxing, or a pain in the grass? A UT-Austin Community and Regional Planning graduate student is working on a project to help improve your neighborhood's natural resources and will be sharing information with the City's Watershed Protection Department. Your opinion is needed! Please visit http://tinyurl.com/UTexasSurvey to take a short survey and enter to win a $50 gift card. For questions, please contact Ian Johnston at iantjohnston@utexas.edu or (512) 553-1979.

Is your yard beautiful, relaxing, or a pain in the grass? A UT Austin Community and Regional Planning graduate student is working on a project to help improve your neighborhood's natural resources and will be sharing information with the City's Watershed Protection Department. More than 100 neighbors in Crestview, Highland, and Skyview have taken the survey – submit YOUR opinion by July 31! Please visit http://tinyurl.com/UTexasSurvey to take a short survey and enter to win a $50 gift card. For questions, please contact Ian Johnston at iantjohnston@utexas.edu or (512) 553-1979.

Appendix G: Survey Postcard

PLEASE TAKE A SHORT SURVEY!

Feedback will be used to guide future improvements for your neighborhood creek!

You could **WIN** a giftcard!

WHAT IS YOUR YARD...

An area for recreation and relaxation? A place to grow food? A beautiful landscape? A hassle? Something else? What would you like it to be?

PLEASE PARTICIPATE IN A SHORT SURVEY, AT

http://tinyurl.com/UTexasSurvey, created by a University of Texas–Austin graduate student. Only three neighborhoods are receiving this survey. Your voice is important!

For more information contact:
Ian Johnston
iantjohnston@utexas.edu or
512.553.1979

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Agency Name
Permit NO. 1308

Appendix H: List of Organizations

Do you consider yourself an active member of any community, religious, trade, environmental, or social organizations?
United Way
St. Austin Catholic Church, Institute of Electrical and Electronic Engineers
Dungeons and Dragons Group
Big Brother Big Sister
Professional-freedance Austin, Women Communicators of Austin. Alumni- Georgetown U, UT LBJ School, UT Journalism School
Church (St. Martin's Lutheran), TOPS
St. Louis Catholic Church
Pita Austin, National Federation for the Blind, many rescue organizations
engineering meetup groups, bowling league, professional editor associations
Worked for www.ecologic.org ; member of Lamar Middle School Campus Advisory Council; member of Rotary http://www.austincrc.org/; active member/fellow of www.switzernetwork.org
AURA, Sierra Club, Bike Austin, Midtown NA, St. Austin parish
Church of the Cross, Texas Renal Coalition
Highland Neighborhood Association
Art and film groups, reading groups, professional associations
Bike Austin, Highland NA
St. Martin's Lutheran Church, Highland Neighborhood Association
Hyde Park Baptist Church Bat City Pinball Club
neighborhood association, volunteer for neighborhood projects, belong to neighborhood church, active at kid's school
LGBT Community Crestview Neighborhood Association Midtown Austin Neighborhood Association
Unitarian Universalist Church.
church, trade org
catholic
Society for Creative Anachronism
A member of a number of local groups but not 'active' other than donating money yearly.
I go to the JCC.
Highland Neighborhood Association, Ridgetop Elementary School PTA and CAC
Austin Justice Coaliiton, Educators in Solidarity, Black Pflugerville
N/A
TreeFolks International Society of Arboriculture, Texas chapter AISD parent volunteer Crestview Methodist Church
Boy Scouts of America

Mentoring at nearby elementary school. Former board member of TreeFolks.
Highland, Skyview and Ridgetop Neighborhood Associations, Triathlon Groups, Church
Church
First Unitarian Universalist Church of Austin, Austin Yacht Club
Volunteer @ my church
Democratic Party
Assistance League of Austin St. John's United Methodist Church Wildflower Center
Gay rights groups.
An active member of a local Church that is concerned and active in social justice issues
An active member of our neighborhood; e.g. engaged in applying for grants locally.
church, association, meetup groups
Finding the time is hard.
Church, park days, park playground committee, school PTA,
Neighborhood orgs, PTA, bike Austin
Unitarian Universalist church
Active in my neighborhood association as well as several trade/industry groups related to my work.
I don't want to list organizations.
Austin Ridge Riders Mountain Bike Club
Highland Neighborhood Assoc. Proactive Highland Political Group Sierra Club-just starting :)
Cinematic Symphony Neighborhood Association Wildflower Center Member
NSCNA
Church, Ten Thousand Villages of Austin
Favor environmental groups, children's charities and refugee assistance.
Texas NORML
Austin Animal Center
Pond society
Local radio and tv stations affiliates Church (Subscribe to green energy through CoA)
St. John's UMC Austin Palete Club CNA
Austin Pond Society
N.A.M.I. God'skitchen, Crestview neighborhood association. Public radio public t.v.
Haam Kerrville Folk Festival Foundation

Volunteer at church sometimes
Soccer teams, dirt bike riding
St Austin Parish
Kab and apf

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